



Biological Assessment Report

Buffalo Creek

McDonald and Newton Counties, Missouri

Fall 2019 and Spring 2021

Prepared for:

Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

Prepared by:

Missouri Department of Natural Resources
Division of Environmental Quality
Environmental Services Program
Water Quality Monitoring Section

Table of Contents

Section	Page
1.0 Introduction	1
1.1 Study Area	2
1.2 Station Descriptions.....	3
2.0 Methods	5
2.1 Stream Habitat	5
2.2 Stream Physicochemistry	5
2.3 Bioassessment.....	6
2.4 Warm/Cold Criteria	6
2.5 Quality Assurance/Quality Control (QA/QC) of Bioassessment Data.....	7
2.5.1 Data Collection	7
2.5.2 Meter Calibration.....	7
2.5.3 Macroinvertebrate Subsampling.....	7
2.5.4 Macroinvertebrate Data Entry	7
2.5.5 Duplicate Sample Collection.....	7
3.0 Bioassessment Results.....	8
3.1 Land Use.....	8
3.2 Stream Habitat	10
3.3 Physicochemical Analysis	11
3.4 Biological Assessment.....	14
3.4.1 Macroinvertebrate Community Composition.....	14
3.4.2 Investigation of Stream Temperature Class Designation	22
3.4.3 Macroinvertebrate Stream Condition Index (MSCI) Scores	25
3.5 Duplicate Sample Results.....	26
4.0 Discussion.....	27
4.1 Land Use.....	27
4.2 Stream Habitat	27
4.3 Physicochemical Analysis	27
4.4 Biological Assessment and Macroinvertebrate Community Composition	28
5.0 Conclusions	30
6.0 References Cited.....	31

Tables

Table 1. Land Use Percentage of Buffalo Creek Station Watersheds and Habitat Survey Bioreference Stream Station	9
Table 2. Results from Stream Habitat Assessment on Buffalo Creek and Mikes Creek during the Fall 2019 Habitat Survey	10
Table 3. Buffalo Creek Fall 2019 In Situ and Physicochemical Results	12
Table 4. Buffalo Creek Spring 2021 In Situ and Physicochemical Results.....	13
Table 6. Fall 2019 Buffalo Creek Riffle/Pool Macroinvertebrate Composition.....	15
Table 7. Spring 2021 Buffalo Creek Riffle/Pool Macroinvertebrate Composition	19
Table 8. Fall 2019 Buffalo Creek Riffle/Pool Metric Values and Scores Using Ozark/Neosho Warm-Water Biological Criteria	25
Table 9. Spring 2021 Buffalo Creek Riffle/Pool Metric Values and Scores Using Ozark/Neosho Warm-Water Biological Criteria	26

Figures

Figure 1. Location of Buffalo Creek within the Ozark/Neosho EDU	2
Figure 2. Buffalo Creek Stations with Surrounding Municipalities	4
Figure 3. 2019 NLCD Land Use of the Buffalo Creek Watershed	8
Figure 4. Fall 2019 Percent of Taxa by Functional Feeding Group	16
Figure 5. Fall 2019 Percent Sensitive Taxa by Biotic Index	17
Figure 6. Spring 2021 Percent of Taxa by Functional Feeding Group	20
Figure 7. Spring 2021 Percent Sensitive Taxa	21
Figure 8. Location of Temperature Loggers on Buffalo Creek	23
Figure 9. Temperature Logger Data from Buffalo Creek	24

Attachments

Appendix A	Macroinvertebrate Database Bench Sheet Report
Appendix B	Fall and Spring BIOREF Biological Metric Values

1.0 Introduction

At the request of the Missouri Department of Natural Resources (**MoDNR**) Water Protection Program (**WPP**), the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a biological assessment and habitat study of Buffalo Creek during the fall of 2019 and spring of 2021. Consecutive sampling between seasons was not possible due to travel restrictions for MoDNR employees during the COVID-19 pandemic. Fall sampling occurred on October 1-2, 2019, and consisted of macroinvertebrate sampling, stream habitat assessments, and water quality sampling. During spring 2021, sampling was conducted on March 8-9, 2021, and consisted of macroinvertebrate and water quality sampling. A habitat assessment of the reference stream, Mikes Creek, was conducted on June 6, 2019, to compare with Buffalo Creek's habitat. Sampling was completed by Brandy Bergthold, Ken Lister, Rory Mott, and Carl Wakefield.

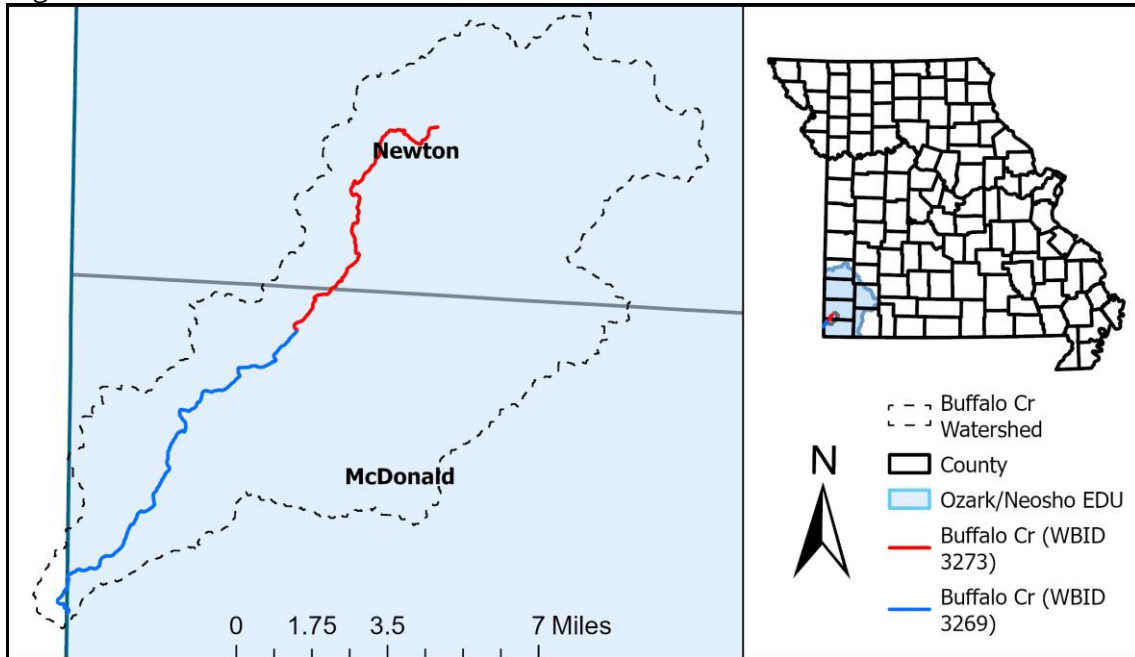
The assigned reach of Buffalo Creek is categorized as a class P stream, which is defined as a stream that maintains permanent flow even in drought periods (MoDNR 2018f). This reach comprises two separate water body identification (**WBID**) numbers. WBID 3273 is the upstream warm-water section, and WBID 3269 is the downstream cold-water section (MoDNR 2018f). The upstream warm-water reach travels through Newton and McDonald counties from Section 5, T23N, R33W to Section 14, T24N, R33W, and the cold-water reach in McDonald County runs from Section 7, T23N, R33W to the Oklahoma border. Buffalo Creek 3273 has the following designated uses based on the 2018 Missouri Water Quality Standards (**WQS**; MoDNR 2018f): irrigation, livestock and wildlife watering; protection of warm-water habitat and human health protection; cool water fisheries habitat; category A whole body contact recreation; and secondary contact recreation. Buffalo Creek 3269 has the same designated uses with the exception of having a cold-water habitat designation.

Buffalo Creek (WBID 3273) is listed on Missouri's 303(d) List of Impaired Waters for fish bioassessment and unknown pollutant(s) in the water (MoDNR 2019a). Fisheries data collected by the Missouri Department of Conservation (**MDC**) indicate poor fish diversity in Buffalo Creek (WBID 3273). MDC's Fish Index of Biotic Integrity (Doisy et al. 2008) can be used as part of the MoDNR weight of evidence analysis to determine whether a stream attains its aquatic life use designation (MDNR 2019a). MoDNR determined that the available data were sufficient in classifying Buffalo Creek as an impaired stream.

1.1 Study Area

Buffalo Creek is in the Ozark/Neosho Ecological Drainage Unit (**EDU**, Figure 1). An EDU is a region that contains similar biological communities and habitat conditions. Buffalo Creek was assessed for this study using biological criteria comparing all study sites to Ozark/Neosho EDU wadeable/perennial biological criteria reference (**BIOREF**) streams.

Figure 1. Location of Buffalo Creek within the Ozark/Neosho EDU



1.2 Station Descriptions

Six stations were sampled in Buffalo Creek. Their numerical descriptions are derived from the distance upstream in river miles from the WBID termination point. The following locations and descriptions correspond with the station labels in Figure 2. Global Position Satellite (**GPS**) coordinates are given in Universal Transverse Mercator (**UTM**) format in Zone 15.

Buffalo Creek Station 3269/2.1 was sampled downstream of Highway 43/76 in McDonald County. UTM coordinates were collected at the upstream boundary of the sample reach and are E356588, N4059372. The legal description is SE1/4 Sec. 4, T. 22 N., R. 34 W.

Buffalo Creek Station 3269/6.4 was sampled downstream of the Klondike Road bridge crossing in McDonald County. UTM coordinates were taken at the midsection of the sample reach and are E359749, N4064447. The legal description is NE1/4 Sec. 23, T. 23 N., R. 34 W.

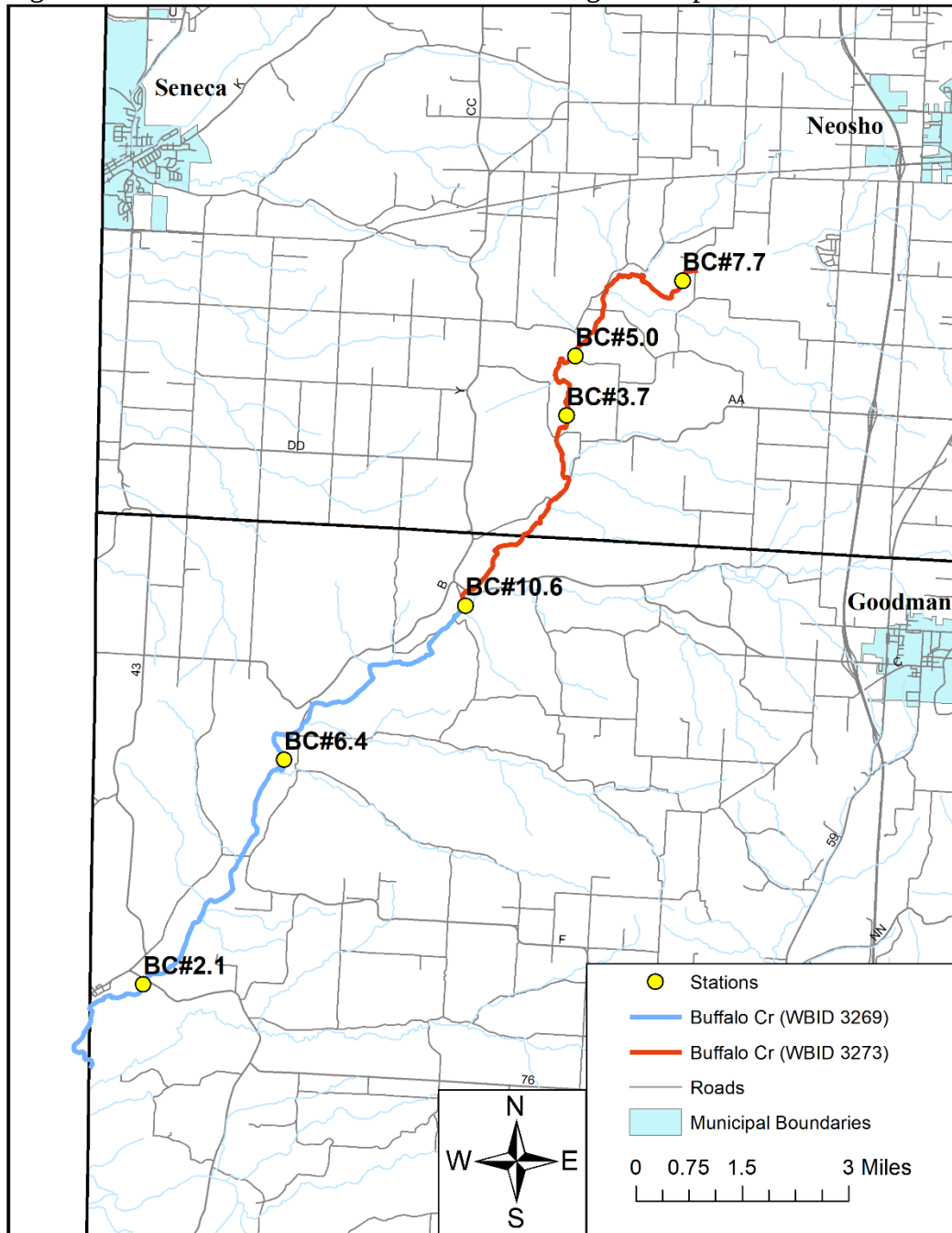
Buffalo Creek Station 3269/10.6 was sampled south of the Highway B bridge crossing in McDonald County. UTM coordinates were taken at the upstream boundary of the sample reach, just below the Sugar Fork confluence. They are E363884, N4068006. The legal description is SW1/4 Sec. 5, T. 23 N., R. 33 W.

Buffalo Creek Station 3273/3.7 was sampled upstream of the Rosebay Drive bridge crossing in Newton County. UTM coordinates were taken at the midsection of the sample reach and are E366214, N4072381. The legal description is NW1/4 Sec. 28 T. 24 N., R. 33 W.

Buffalo Creek Station 3273/5.0 was sampled downstream of the Queen's Lace bridge crossing in Newton County. UTM coordinates were taken at the midsection of the sample reach and are E366648, N4074062. The legal description is NW1/4 Sec. 21, T. 24 N., R. 33 W.

Buffalo Creek Station 3273/7.7 was sampled downstream of the Hereford Road bridge crossing in Newton County. UTM coordinates were taken at the upstream boundary of the sample reach and are E368869, N4075443. The legal description is NE1/4 Sec. 15, T. 24 N., R. 33 W.

Figure 2. Buffalo Creek Stations with Surrounding Municipalities



2.0 Methods

Macroinvertebrate and water quality sampling was conducted during fall 2019 and spring 2021 by WQMS's Aquatic Bioassessment Unit. Methods for stream habitat assessments, biological assessments, dissolved metals, and physicochemical water quality are included in this section. All samples were handled according to the applicable MoDNR ESP Standard Operating Procedure (**SOP**) or Project Procedure (**PP**).

2.1 Stream Habitat

Stream habitat is a foundational filter for aquatic communities and as such determines which species can be supported. Stream habitat was assessed using procedures for riffle/pool streams as described in the *Stream Habitat Assessment Project Procedure* (**SHAPP**, MoDNR 2019j). The total habitat score equaled the sum of scores for each of 10 habitat measures assessed along 10 separate sections of the stream reach. A stream reach was defined as 20 times the average width of the stream. The study stream habitat scores were compared to the BIOREF habitat score at Mikes Creek in McDonald County. Study stream habitat scores that are ≥ 75 percent of reference stream scores should be able to support biological communities comparable to the reference stream (MoDNR 2019j).

2.2 Stream Physicochemistry

Physicochemical water samples collected in fall 2019 and spring 2021 were handled according to the appropriate MoDNR ESP SOPs. Physicochemical water quality results were examined by season and station for *in situ* field measurements or grab samples collected in accordance with the SOP MDNR-ESP-001, *Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations* (MoDNR 2019d). All samples were kept on ice during transport to ESP.

Water quality parameters were measured and water quality samples were collected and returned for analyses at the ESP laboratory in Jefferson City. Turbidity (NTU, MoDNR 2018a) was measured in the ESP, WQMS biology laboratory. Discharge (cubic feet per second-**cfs**, MoDNR 2019f), DO (mg/L, MoDNR 2019e), conductivity ($\mu\text{S}/\text{cm}$, MoDNR 2018d), pH (MoDNR 2018b), and temperature ($^{\circ}\text{C}$, MoDNR 2018c), were measured in the field. The ESP Chemical Analysis Section conducted analyses for the following: nitrate plus nitrite-nitrogen, total nitrogen, total phosphorus, ammonia as nitrogen (**N**), sulfate, chloride, total suspended solids/non-filterable residue, dissolved calcium, and dissolved magnesium (all parameters reported in mg/L). Physicochemical water parameters were compared among stations as well as with Missouri's WQS (MoDNR 2018f). Nutrient values were compared to U.S. EPA's recommended nutrient values for rivers and streams in nutrient ecoregion XI (USEPA 2000).

Metals can exist dissolved in solution or suspended in particulate forms in a water body. Surface water samples were collected and analyzed for dissolved As, Ba, Ca, Cd, Co, Cu, Fe, Mg, Mn, Ni, Pb, and Zn, and the results were compared to Missouri WQS criteria based on water hardness. Interpretation of acceptable limits in the WQS may be

dependent on a stream's classification and beneficial uses as designated in the WQS (MoDNR 2018f).

2.3 Bioassessment

Macroinvertebrate sampling was conducted according to the *Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP)*, MoDNR 2019c). Buffalo Creek is considered a riffle/pool dominated system. The three standard habitats sampled at all locations were flowing water over coarse substrate (**CS**), non-flowing water over depositional substrate (**NF**), and submerged rootmat (**RM**). Macroinvertebrate samples were subsampled in the laboratory and identified to taxonomic levels as specified in MoDNR's *Taxonomic Levels for Macroinvertebrate Identifications* SOP (MoDNR 2019g) to develop biological metrics (MoDNR 2019c). Macroinvertebrate bench sheet data are included in Appendix A.

Buffalo Creek macroinvertebrate data were evaluated relative to BIOREF streams in the Ozark/Neosho EDU (Appendix B). Biological criteria are calculated separately for the fall (mid-September through mid-October) and spring (mid-March through mid-April) index periods. The SMSBPP provides details on the calculation of metrics and scoring of the multi-metric Macroinvertebrate Stream Condition Index (**MSCI**). The four components of the MSCI are Taxa Richness (**TR**); Ephemeroptera, Plecoptera, and Trichoptera Taxa (**EPTT**); Biotic Index (**BI**); and the Shannon Diversity Index (**SDI**). An MSCI score of 16-20 is considered fully supporting, 10-14 partially supporting, and 4-8 is non-supporting of the protection of warm-water aquatic habitat beneficial use designation as listed in the Missouri WQS (MoDNR 2018f).

2.4 Warm/Cold Criteria

To properly score bioassessment data, the cold-water classification of Buffalo Creek WBID 3269 was evaluated by closely examining thermal data. YSI Model 600 OMS V1 data loggers were deployed near three sample sites for a two-week period from July 25, 2022, to August 10, 2022, during anticipated summertime high temperature periods to measure temperature every 15 minutes. Data logger use was conducted following SOP MDNR-ESP-104 *Continuous Monitoring of Water Quality Using a Dissolved Oxygen, Specific Conductivity, pH, Turbidity, Rhodamine Dye, and Temperature Data Logger* (MoDNR 2018e).

Loggers were placed in WBID 3269 near macroinvertebrate sample sites described in Section 1.2. Deployment locations were prioritized based on ease of access, permanent flow, and the field staff's discretion (e.g. staying away from popular use areas to minimize risk of loss). Logger A was set downstream of station 3269/2.1 and the Highway 76/43 bridge. Logger B was located above station 3269/6.4 and the Klondike Road bridge. Logger C was placed below station 32.69/10.6 and upstream of the Price Ridge Road crossing.

2.5 Quality Assurance/Quality Control (QA/QC) of Bioassessment Data

2.5.1 Data Collection

Data were collected following guidelines in *Quality Assurance/Quality Control for Environmental Data Collection* (MoDNR 2019i).

2.5.2 Meter Calibration

Field meters used to collect temperature, dissolved oxygen, pH, and specific conductance were maintained in accordance with *Quality Control Procedures for Checking Water Quality Field Instruments* (MoDNR 2016). Quality control measures for multiparameter data loggers were conducted in accordance with *Continuous Monitoring of Water Quality Using a Dissolved Oxygen, Specific Conductivity, pH, Turbidity, Rhodamine Dye, and Temperature Data Logger* (MoDNR 2018e).

2.5.3 Macroinvertebrate Subsampling

Steps to assure accuracy of organism removal from sample debris were performed using methods described in the SMSBPP (MoDNR 2019c).

2.5.4 Macroinvertebrate Data Entry

Macroinvertebrate data were entered into the WQMS macroinvertebrate database in accordance with *Quality Control Procedures for Data Processing* (MoDNR 2019i).

2.5.5 Duplicate Sample Collection

Duplicate samples are obtained from the same location and time as the true sample following the same procedures in accordance with *Quality Assurance/Quality Control for Environmental Data Collection* (MoDNR 2019h). The true samples and the duplicate samples are analyzed for the same set of parameters. A duplicate is used to assess the precision associated with sampling methodology, sample heterogeneity, and analytical procedures (MoDNR 2019h). Duplicate physicochemical samples were collected at Buffalo Creek station 3273/3.7 during fall 2019 and station 3273/7.7 during spring 2021.

3.0 Bioassessment Results

3.1 Land Use

The overall land use of the Buffalo Creek drainage is presented graphically in Figure 3. Table 1 lists the land use percentages of Buffalo Creek station drainages, the habitat assessment reference station, and the Ozark/Neosho EDU. All stations, including the habitat assessment reference station, are dominated by deciduous forest and hay/pasture land use. These data are derived from 2019 National Land Cover Database (NLCD) imaging (Dewitz 2021).

Figure 3. 2019 NLCD Land Use of the Buffalo Creek Watershed

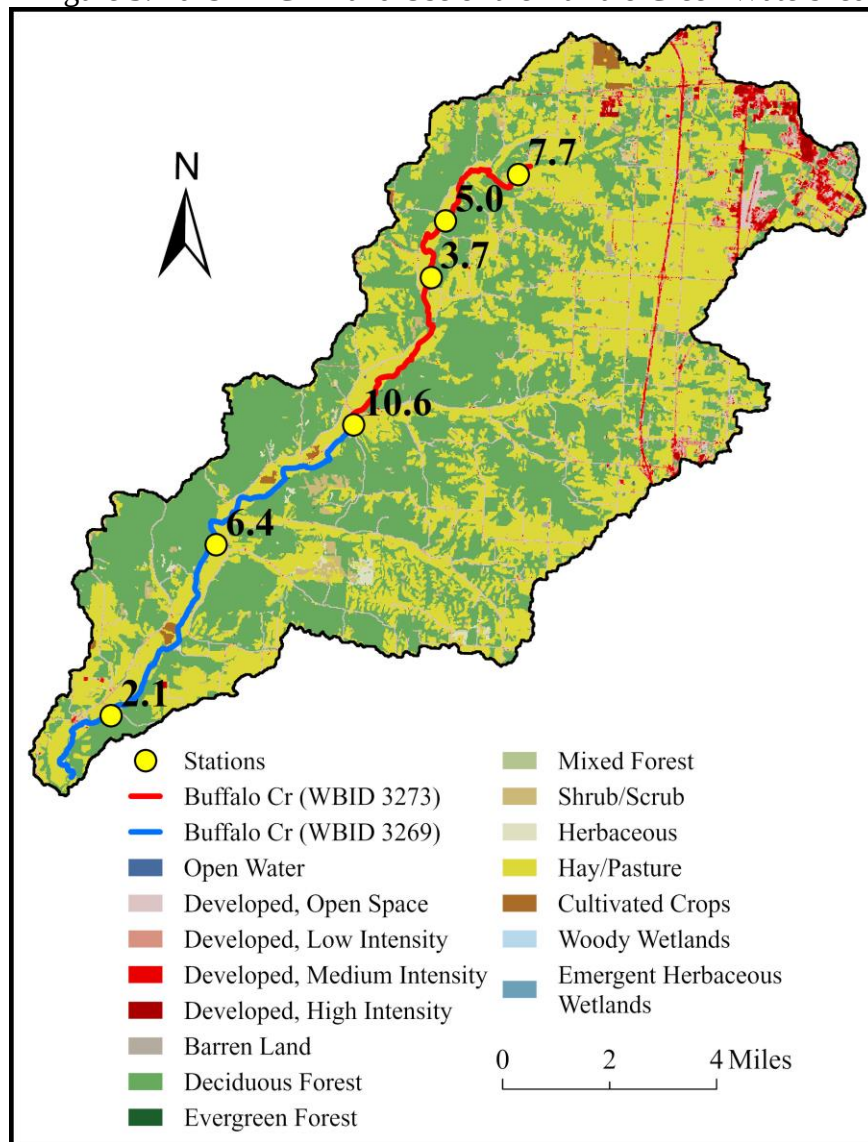


Table 1. Land Use Percentage of Buffalo Creek Station Watersheds and Habitat Survey Bioreference Stream Station

Stream Habitat Parameters	Buffalo Cr 3269/2.1	Buffalo Cr 3269/6.4	Buffalo Cr 3269/10.6	Buffalo Cr 3273/3.7	Buffalo Cr 3273/5.0	Buffalo Cr 3273/7.7	Mikes Cr BIOREF
Open Water	0.04	0.04	0.04	0.05	0.05	0.04	0.00
Developed, Open Space	4.95	5.11	5.40	5.95	6.11	7.37	3.71
Developed, Low Intensity	2.10	2.42	2.92	4.27	4.48	6.23	0.39
Developed, Medium Intensity	1.52	1.81	2.24	3.70	3.91	5.87	0.15
Developed, High Intensity	0.58	0.70	0.87	1.66	1.75	2.83	0.04
Barren Land	0.08	0.09	0.11	0.17	0.18	0.08	0.03
Deciduous Forest	45.08	43.18	40.11	30.63	29.61	25.85	74.54
Evergreen Forest	0.01	0.01	0.00	0.00	0.00	0.00	0.11
Mixed Forest	0.24	0.24	0.28	0.33	0.35	0.40	0.99
Shrub/Scrub	1.09	1.14	0.84	0.79	0.83	1.05	1.12
Herbaceous	0.59	0.59	0.21	0.24	0.25	0.33	0.87
Hay/Pasture	43.10	44.15	46.46	51.33	51.54	49.94	18.03
Cultivated Crops	0.46	0.44	0.48	0.83	0.88	0.02	0.01
Woody Wetlands	0.14	0.07	0.03	0.05	0.05	0.00	0.01
Emergent Herbaceous Wetlands	0.01	0.00	0.00	0.01	0.01	0.04	0.00

3.2 Stream Habitat

Habitat assessment scoring results are found in Table 2. If the study station SHAPP score is ≥ 75 percent of the control station score, it is considered to contain comparable habitat as the control station (MoDNR 2019j). Comparable habitats should support similar biological communities. All stations scored ≥ 75 percent of the habitat reference stream SHAPP score. Buffalo Creek generally had excellent epifaunal substrate with good riffle quality. Buffalo Creek stations 3273/5.0 and 3273/7.7 had little to no riparian zones. Streambank stability generally scored worse in the upper reach (i.e. WBID 3273) and vegetative protection was lacking in all sites.

Table 2. Results from Stream Habitat Assessment on Buffalo Creek and Mikes Creek during the Fall 2019 Habitat Survey

Stream Habitat Parameters	Buffalo Cr 3269/2.1	Buffalo Cr 3269/6.4	Buffalo Cr 3269/10.6	Buffalo Cr 3273/3.7	Buffalo Cr 3273/5.0	Buffalo Cr 3273/7.7	Mikes Cr BIOREF
Habitat Assessment Date	10/1/2019	10/1/2019	10/2/2019	10/2/2019	10/2/2019	10/2/2019	8/6/2019
Epifaunal Substrate/Available Cover	20	20	20	20	20	20	18
Embeddedness	20	20	20	19	19	17	19
Velocity/Depth Regime	20	20	20	20	20	17	16
Sediment Deposition	14	15	15	12	14	14	13
Channel Flow Status	10	10	15	15	8	10	11
Channel Alteration	20	20	18	20	19	20	20
Riffle Quality	20	20	20	20	15	20	12
Left Bank Stability	10	9	4	9	6	5	9
Right Bank Stability	9	10	8	8	5	7	9
Left Bank Vegetative Protection	0	1	0	0	0	1	0
Right Bank Vegetative Protection	0	2	0	0	0	1	0
Left Bank Riparian Zone Width	8	2	10	7	0	1	10
Right Bank Riparian Zone Width	8	10	9	8	0	1	10
Total Habitat Score	159	159	159	158	126	134	147
Percent of BIOREF Score	108.2	108.2	108.2	107.5	85.7	91.2	-

3.3 Physicochemical Analysis

Discharge, *in situ* field measurements, water quality results, and dissolved metals analysis for Buffalo Creek stations are presented in Tables 3 and 4. No WQS violations occurred during either field season (MoDNR 2018f). Although there are currently no nutrient criteria in Missouri for streams and rivers, a total maximum daily load (TMDL) study for total nitrogen and total phosphorus was approved March 26, 2004, for the Elk River Basin, which includes the Buffalo Creek watershed (MoDNR 2004). Target nutrient values listed in the TMDL are 0.06 mg/L for total phosphorus and 1.0 mg/L for total nitrogen (MoDNR 2004). During fall 2019, total nitrogen exceeded the TMDL target levels at all sites. Stations 3273/5.0 and 3273/7.7 exceeded the total phosphorus target, and the 3273/3.7 phosphorus concentration was equal to the target. In spring 2021, all stations had total nitrogen concentrations that were above the TMDL target; however, all phosphorus levels were below the target.

Nutrient parameters in Buffalo Creek were also compared to the U.S. EPA's December 2000 publication *Ambient Water Quality Criteria Recommendations for Rivers and Streams in Nutrient Ecoregion XI* (USEPA 2000). Buffalo Creek study stations are located in the Ozark Highlands Level III ecoregion. At the Level IV ecoregion extent, the sample reach occupies the Elk River Hills, a region containing "dissected hills, entrenched valleys and areas ranging from rolling, irregular plains to steep slopes" (Chapman et al. 2002). The recommended values for the Ozark Highlands (i.e. Level III ecoregion #39) are 0.239 mg/L nitrite+nitrate, 0.379 mg/L total nitrogen, 0.007 mg/L (rounded from 6.625 µg/L) total phosphorus, and 1.425 NTU turbidity (USEPA 2000).

In fall 2019, all Buffalo Creek stations surpassed EPA's recommended values for nitrite+nitrate and total nitrogen. Additionally, stations 3273/3.7, 3273/5.0, and 3273/7.7 exceeded EPA's recommended total phosphorus value (Table 3). In spring 2021, all Buffalo Creek stations exceeded EPA's recommend value for nitrite+nitrate, total phosphorus, and total nitrogen (Table 4). All stations, excluding station 3269/10.6, exceed EPA's recommend value for turbidity during spring 2021 sampling (Table 4).

Table 3. Buffalo Creek Fall 2019 *In Situ* and Physicochemical Results

	BC 3269/2.1	BC 3269/6.4	BC 3269/10.6	BC 3273/3.7	BC 3273/3.7 (Duplicate)	BC 3273/5.0	BC 3273/7.7
Collection Date	10/1/19	10/1/19	10/2/20	10/2/19	10/2/19	10/2/19	10/2/19
<i>In situ</i> Field Measurements							
Flow (cfs)	94.71	78.36	48.07	16.34	16.41	17.01	6.35
Temperature (°C)	22.5	22.6	20.6	21.2	21.2	22.8	22.9
Dissolved Oxygen (mg/L)	7.84	8.24	7.35	7.26	7.23	8.35	9.01
Conductivity (µS/cm)	312	308	310	292	292	293	281
pH (standard units)	7.8	7.9	7.6	7.9	7.8	7.8	8.2
Turbidity (NTU)	0.71	1.1	1.0	1.1	1.2	1.1	1.2
Lab Analysis							
Ammonia (mg/L)	<0.02 ND	<0.02 ND	<0.02 ND	<0.02 ND	0.042 ⁰⁵	<0.02 ND	<0.02 ND
Nitrite+Nitrate (mg/L)	2.35⁰⁹	2.08⁰⁹	2.04⁰⁹	1.85⁰⁹	2.00⁰⁹	2.07⁰⁹	1.94⁰⁹
Total Nitrogen (mg/L)	2.36	2.11	1.98	2.10	2.11	2.06	2.06
Total Phosphorus (mg/L)	<0.005 ND	<0.005 ND	<0.005 ND	0.060	0.065	0.066	0.074
TSS (mg/L)	<5.00 ND	5.00	<5.00 ND	<5.00 ND	<5.00 ND	<5.00 ND	<5.00 ND
Chloride (mg/L)	6.35	6.91	7.70	7.32	7.24	7.38	9.08
Hardness (mg/L)	142	140	142	133	132	125	132
Sulfate (mg/L)	6.48	5.64	6.27	7.22	7.02	7.69	7.35
Dissolved Metals Analysis							
Calcium (mg/L)	53.6	53.3	53.8	49.7	49.4	46.6	49.4
Iron (µg/L)	<2.50 ND	<2.50 ND	17.6	3.97 ⁰⁵	3.82 ⁰⁵	5.77	5.79
Magnesium (mg/L)	1.98	1.79	1.83	2.07	2.05	2.20	2.04
Arsenic (µg/L)	<0.50 ND	<0.50 ND	<0.50 ND	<0.50 ND	<0.50 ND	<0.50 ND	<0.50 ND
Barium (µg/L)	55.3	56.1	54.3	60.9	60.2	58.2	59.3
Cadmium (µg/L)	<0.10 ND	<0.10 ND	<0.10 ND	<0.10 ND	<0.10 ND	<0.10 ND	<0.10 ND
Cobalt (µg/L)	<1 ND	<1 ND	<1 ND	<1 ND	<1 ND	<1 ND	<1 ND
Copper (µg/L)	0.50 ⁰⁵	<0.50 ND	0.64 ⁰⁵	<0.50 ND	0.55 ⁰⁵	0.51 ⁰⁵	<0.50 ND
Lead (µg/L)	<0.50 ND	<0.50 ND	<0.50 ND	<0.50 ND	<0.50 ND	<0.50 ND	<0.50 ND
Manganese (µg/L)	0.68 ⁰⁵	1.20	<0.50 ND	1.03	1.63	1.14	1.93
Nickel (µg/L)	2.00	2.00	1.99	1.86	2.00	1.91	1.94
Zinc (µg/L)	0.64 ⁰⁵	0.50 ⁰⁵	0.90 ⁰⁵	0.54 ⁰⁵	0.98 ⁰⁵	<0.50 ND	0.52 ⁰⁵

Qualifiers are ND - Not detected at reported value; 05 - Estimated value, detected below the Practical Quantitation Limit (PQL); 09 - Sample was diluted during analysis. Bold values exceed EPA's recommended values (USEPA 2000).

Table 4. Buffalo Creek Spring 2021 *In Situ* and Physicochemical Results

	BC 3269/2.1	BC 3269/6.4	BC 3269/10.6	BC 3273/3.7	BC 3273/5.0	BC 3273/7.7	BC 3273/7.7 (Duplicate)
Collection Date	3/8/21	3/8/21	3/8/21	3/8/21	3/9/21	3/9/21	3/9/21
<i>In situ</i> Field Measurements							
Flow (cfs)	44.30	32.80	21.40	8.05	8.90	3.71	3.46
Temperature (°C)	11.2	11.8	11.4	11.7	9.8	12.2	12.3
Dissolved Oxygen (mg/L)	12.33	12.2	11.64	13.5	11.41	13.23	13.28
Conductivity (µS/cm)	274	274	281	272	287	317	317
pH (standard units)	8.08	8.23	8	8.37	7.76	8.56	8.57
Turbidity (NTU)	1.84	1.80	1.17	2.80	2.05	1.50	1.44
Lab Analysis							
Ammonia (mg/L)	<0.02 ND	<0.02 ND	<0.02 ND	<0.02 ND	<0.02 ND	<0.02 ND	<0.02 ND
Nitrite+Nitrate (mg/L)	1.993	1.975	1.982 ⁰⁹	1.814	1.967	1.951	1.909
Total Nitrogen (mg/L)	1.92	1.9	1.94	1.77	1.96	1.96	1.95
Total Phosphorus (mg/L)	0.037	0.039	0.039	0.046	0.049	0.043	0.037
TSS (mg/L)	<5 ND	<5 ND	<5 ND	<5 ND	<5 ND	<5 ND	<5 ND
Chloride (mg/L)	7.3	7.53	7.78	10.2	12.5	13.5	12.9
Hardness (mg/L)	124	126	128	118	123	128	128
Sulfate (mg/L)	13.4 ¹¹	10.7	6.49 ¹¹	15.6	12.2 ¹¹	11.3	9.74
Dissolved Metals Analysis							
Calcium (mg/L)	46.9	47.6	48.3	44	46	47.5	47.6
Iron (µg/L)	<1 ND	<1 ND	<1 ND	<1 ND	<1 ND	<1 ND	<1 ND
Magnesium (mg/L)	1.78	1.67	1.73	1.9	1.92	2.27	2.21
Arsenic (µg/L)	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND
Barium (µg/L)	38.8	38.2	39.9	43.9	46.9	51.4	52.3
Cadmium (µg/L)	<0.1 ND	<0.1 ND	<0.1 ND	<0.1 ND	<0.1 ND	<0.1 ND	<0.1 ND
Cobalt (µg/L)	<1 ND	<1 ND	<1 ND	<1 ND	<1 ND	<1 ND	<1 ND
Copper (µg/L)	<0.1 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND
Lead (µg/L)	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND
Manganese (µg/L)	1.78 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.52 ⁰⁵	0.53 ⁰⁵	0.51 ⁰⁵
Nickel (µg/L)	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND
Zinc (µg/L)	<0.5 ND	<0.5 ND	0.55 ⁰⁵	<0.5 ND	<0.5 ND	0.59 ⁰⁵	<0.5 ND

Qualifiers are ND - Not detected at reported value; 05 - Estimated value, detected below the Practical Quantitation Limit (PQL); 09 - Sample was diluted during analysis; 11 - Estimated value, matrix interference. Bold values exceed EPA's recommended values (USEPA 2000).

3.4 Biological Assessment

3.4.1 Macroinvertebrate Community Composition

Fall 2019

In fall 2019, Ephemeroptera comprised the majority of macroinvertebrates collected from Buffalo Creek, with station BC 3269/2.1 having the highest with 35.47 percent (Table 6). Prominent Ephemeroptera families included Baetidae and Heptageniidae (Table 6). Baetidae were highly abundant in downstream stations but scarce in upstream stations (Table 6). The mayfly *Baetis* (BI = 6.0) tended to increase in abundance as sampling progressed downstream. *Stenonema benariki* (BI = 3.4) was highly represented in the downstream station 3269/2.1, and *S. femoratum* (BI = 7.5) was more abundant upstream at stations 3273/3.7 and 3273/5.0. Trichoptera were plentiful at all sites (Table 6), with *Cheumatopsyche* (BI = 6.6) being the dominant caddisfly at all sites except station 3269/2.1 where *Oecetis* (BI = 5.7) was most numerous. The order Plecoptera was relatively scarce in Buffalo Creek fall samples (Table 6). Coleoptera, mainly comprising *Stenelmis* (BI = 5.4) and *Psephenus herricki* (BI = 2.5), were numerous at every site. Sample sites 3269/6.4 and 3273/7.7 had high numbers of amphipods.

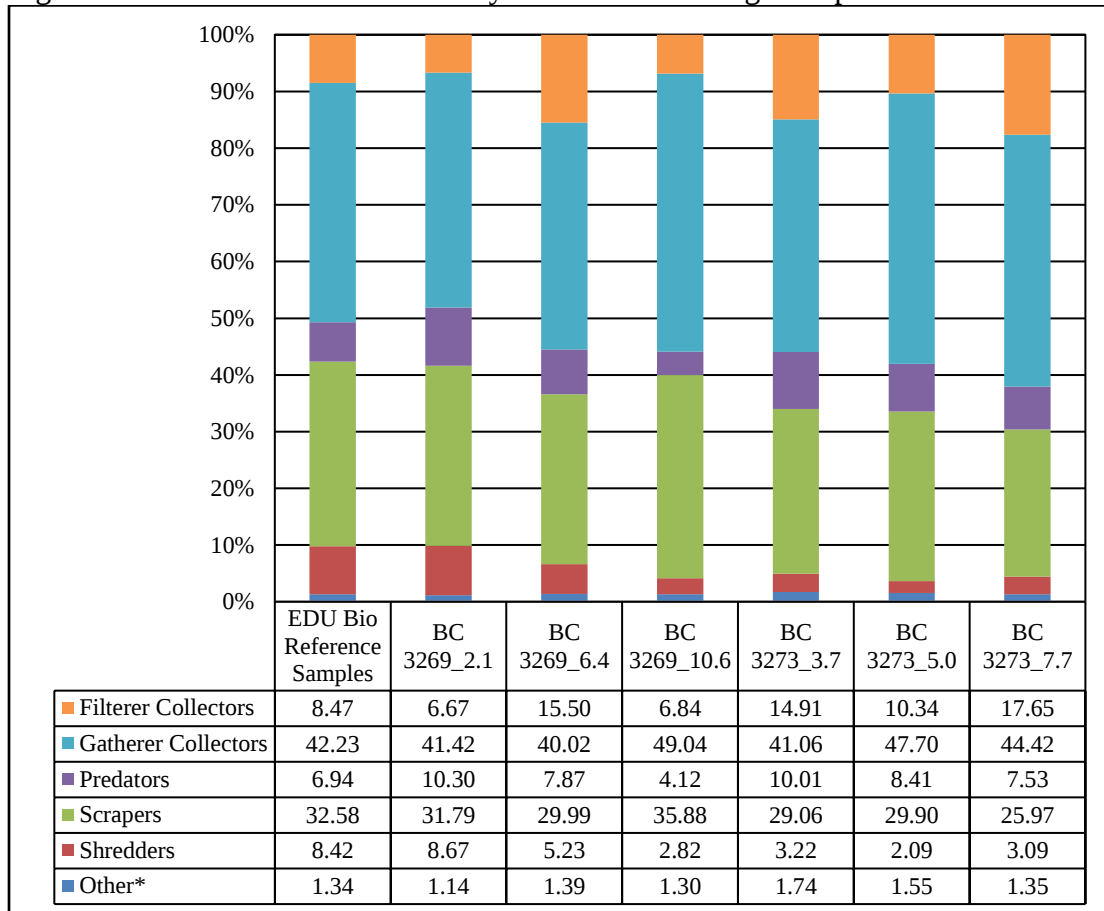
Fall 2019 functional feeding groups (FFG) were primarily composed of gatherer-collectors and scrapers (Figure 4). Sites contained similar FFG compositions throughout the reach. Shredders and scrapers were slightly more numerous downstream, and filterer-collectors were more numerous upstream (Figure 4). During fall 2019, Buffalo Creek contained mostly moderately tolerant (BI 5.0 - 7.4) and tolerant (BI 7.5 - 8.9) invertebrates (Figure 5). There were increases in moderately tolerant taxa abundance and decreased tolerant taxa abundance as stations transitioned downstream.

Table 5. Fall 2019 Buffalo Creek Riffle/Pool Macroinvertebrate Composition

↓Variable	Station→	BC 3269/2.1	BC 3269/6.4	BC 3269/10.6	BC 3273/3.7	BC 3273/5.0	BC 3273/7.7	BIOREF
Taxa Richness		86	82	80	78	72	77	-
Number EPTT		25	27	24	22	27	27	-
% Ephemeroptera		35.47	23.41	28.11	33.94	31.24	29.62	23.89
% Plecoptera		3.70	1.22	0.67	0.47	1.49	1.08	2.05
% Trichoptera		15.11	19.45	7.42	10.79	10.05	18.26	11.54
MSCI Score		18	18	18	16	16	16	-
% Dominant Families								
Baetidae		22.28	15.13	14.93	8.90	4.63	5.32	4.74
Elmidae		11.33	15.27	14.76	11.26	9.18	5.25	7.53
Chironomidae		11.03	13.83	11.18	15.12	10.36	9.71	12.86
Heptageniidae		10.79	5.62	8.76	14.17	16.88	7.76	8.84
Leptoceridae		7.48	3.03	0.08	0.31	1.18	0.72	0.68
Hyalellidae		4.47	6.34	1.08	3.70	4.00	21.21	8.22
Planariidae		3.70	2.88	3.59	3.78	4.71	2.44	0.78
Perlidae		3.70	1.15	0.67	0.47	1.41	1.01	1.92
Psephenidae		3.08	7.49	11.09	8.43	7.93	5.18	16.70
Hydropsychidae		2.85	12.82	4.67	8.90	6.99	14.02	5.34
Pleuroceridae		2.24	0.36	2.25	0	0	0	1.77
Coenagrionidae		1.46	2.74	0	0.63	0.94	0.50	1.11
Asellidae		1.16	0.79	10.84	4.96	9.11	1.29	3.79
Gammaridae		0	0.65	4.00	0.24	5.42	0	0.64
Caenidae		0.31	1.01	3.42	4.17	5.49	12.29	3.41
Isonychiidae		0.39	0.65	0.17	6.06	2.04	3.95	0.13
Leptophlebiidae		1.31	0.65	0.58	0.39	1.65	0.14	6.20

Top 10 families in bold.

Figure 4. Fall 2019 Percent of Taxa by Functional Feeding Group



* “Other” includes parasites, macrophyte piercers, and taxa with no identified FFG.

Figure 5. Fall 2019 Percent Sensitive Taxa by Biotic Index



Spring 2021

In spring 2021, Ephemeroptera was the dominant order among EPTT collected (Table 7), but most Buffalo Creek stations, excluding station 3269/2.1, had lower percentages of Ephemeroptera compared to fall 2019 (Tables 6 and 7). Stations 3273/5.0 and 3273/7.7 both had notable declines in Ephemeroptera abundance from fall 2019 to spring 2021 (Tables 6 and 7). Ephemeroptera families with highest abundance in spring samples were Heptageniidae and Baetidae (Table 7). Station 3269/2.1 had over twice the relative abundance of Heptageniidae than other Buffalo Creek stations, with high numbers of *S. bednariki* (BI = 3.4). The Baetidae genus, *Acentrella* (BI = 4.0), was found in high numbers at all Buffalo Creek stations. Plecoptera taxa richness increased at all stations from fall 2019 to spring 2021, especially at stations 3269/2.1, 3269/6.4, and 3273/3.7 (Table 7). Trichoptera taxa richness was lower at all stations in spring compared to fall 2019. Diptera taxa were found in larger numbers at all sites, with the chironomid group *Cricotopus/Orthocladius* (BI = 8.7) being highly represented, particularly in upstream stations of Buffalo Creek. Asellidae were common in Buffalo Creek spring samples, with high numbers of *Lirceus* (BI = 7.7) at stations 3269/10.6, 3273/3.7, and 3273/5.0 (Table 7).

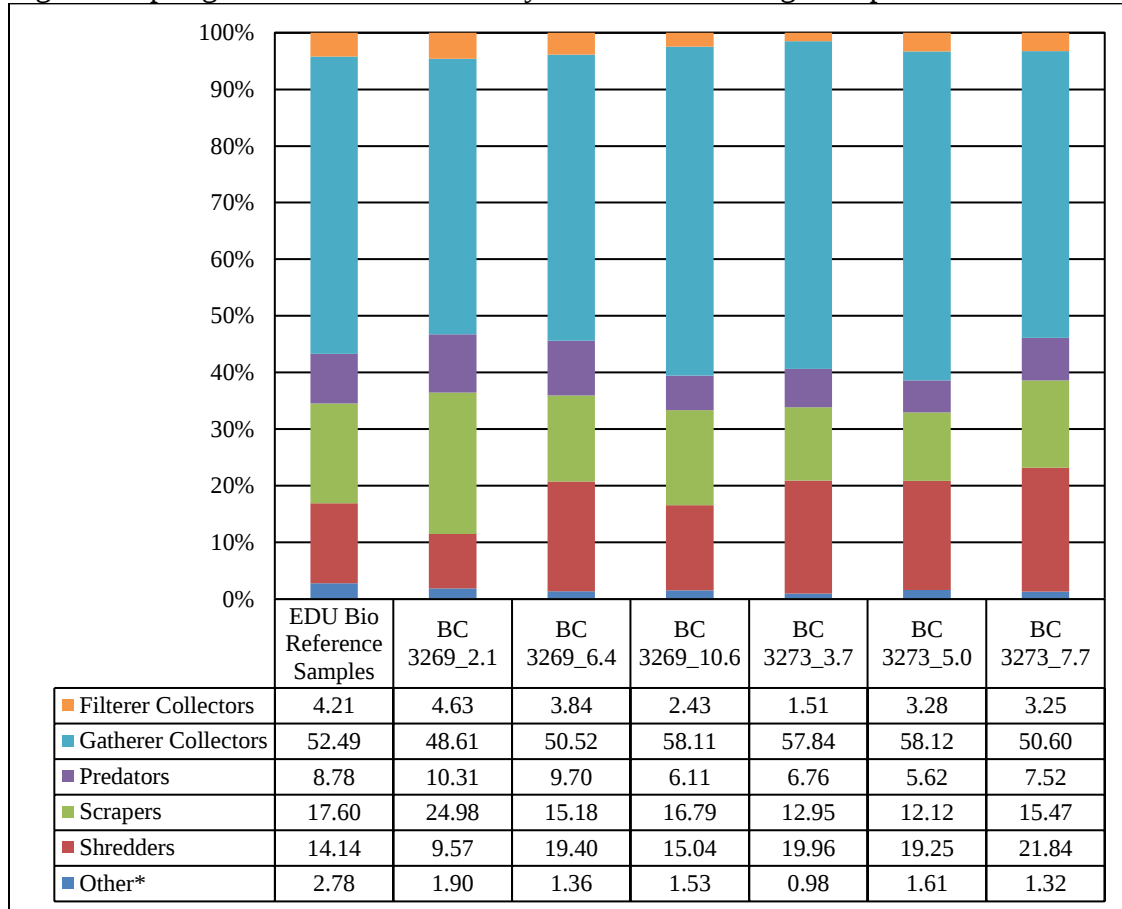
Spring 2021 FFG in Buffalo Creek were made up mainly of gatherer-collectors (Figure 6), accounting for 48.61 percent to 58.12 percent of samples. Despite slight differences in shredders and scrapers, spring 2021 FFG percentages had similar compositions among stations (Figure 6). Buffalo Creek contained primarily tolerant (BI 7.5 - 8.9), moderately tolerant (BI 5.0 - 7.4), and intolerant (BI 2.5 - 4.9) invertebrates in each sample (Figure 7). Traveling from upstream to downstream, intolerant species and very intolerant species representation increased in samples.

Table 6. Spring 2021 Buffalo Creek Riffle/Pool Macroinvertebrate Composition

↓Variable	Station→	BC 3269/2.1	BC 3269/6.4	BC 3269/10.6	BC 3273/3.7	BC 3273/5.0	BC 3273/7.7	BIOREF
Taxa Richness		83	90	68	65	75	76	-
Number EPTT		33	30	15	19	27	21	-
% Ephemeroptera		38.12	18.04	24.56	22.74	15.81	8.99	27.50
% Plecoptera		10.20	7.46	4.39	7.43	2.22	3.93	7.40
% Trichoptera		5.98	5.18	2.95	0.39	2.38	2.53	4.76
MSCI Score		20	20	12	12	14	14	-
% Dominant Families								
Chironomidae		30.61	46.96	33.50	48.99	43.05	58.08	28.56
Heptageniidae		23.10	6.62	6.24	5.73	5.00	1.97	9.91
Baetidae		11.01	6.90	16.88	16.48	10.17	6.46	6.14
Perlidae		9.48	5.78	1.27	2.02	0.64	3.72	1.91
Planariidae		3.13	3.12	3.21	0.13	1.51	1.47	0.78
Ephemerellidae		2.11	0.61	0.42	0.07	0	0	4.00
Asellidae		2.11	2.66	16.88	14.07	19.86	4.28	14.30
Hyaellidae		2.11	3.04	0.93	0.13	4.13	5.48	0.76
Lumbricina (Order)		2.11	0.15	0	0.26	0.16	0	0.09
Elmidae		1.75	2.97	7.34	0.98	3.10	0.91	3.71
Acarina		0.87	4.87	2.36	2.02	2.62	5.62	1.22
Helicopsychidae		0	1.60	1.43	0	0.87	0.21	0.57
Chloroperlidae		0.15	0.46	1.52	1.11	0.16	0	1.79
Nemouridae		0	0.84	0.25	2.41	1.03	0.14	0.92
Perlodidae		0.58	0.38	0.51	1.76	0.40	0.07	1.38
Empididae (undescribed)		0.15	0.99	0.34	1.43	0.79	0.91	0.30
Hydropsychidae		1.02	1.37	0.51	0.13	0.95	0.35	0.96
Physidae		0.51	0.46	0.51	0.13	0.40	3.93	0.07
Psephenidae		0.80	0.53	0.17	0	0.40	0.98	1.36
Leptophlebiidae		0.87	1.45	1.43	0.26	0.08	0.14	5.60
Pleuroceridae		0.44	0.53	1.27	0	0	0	3.17

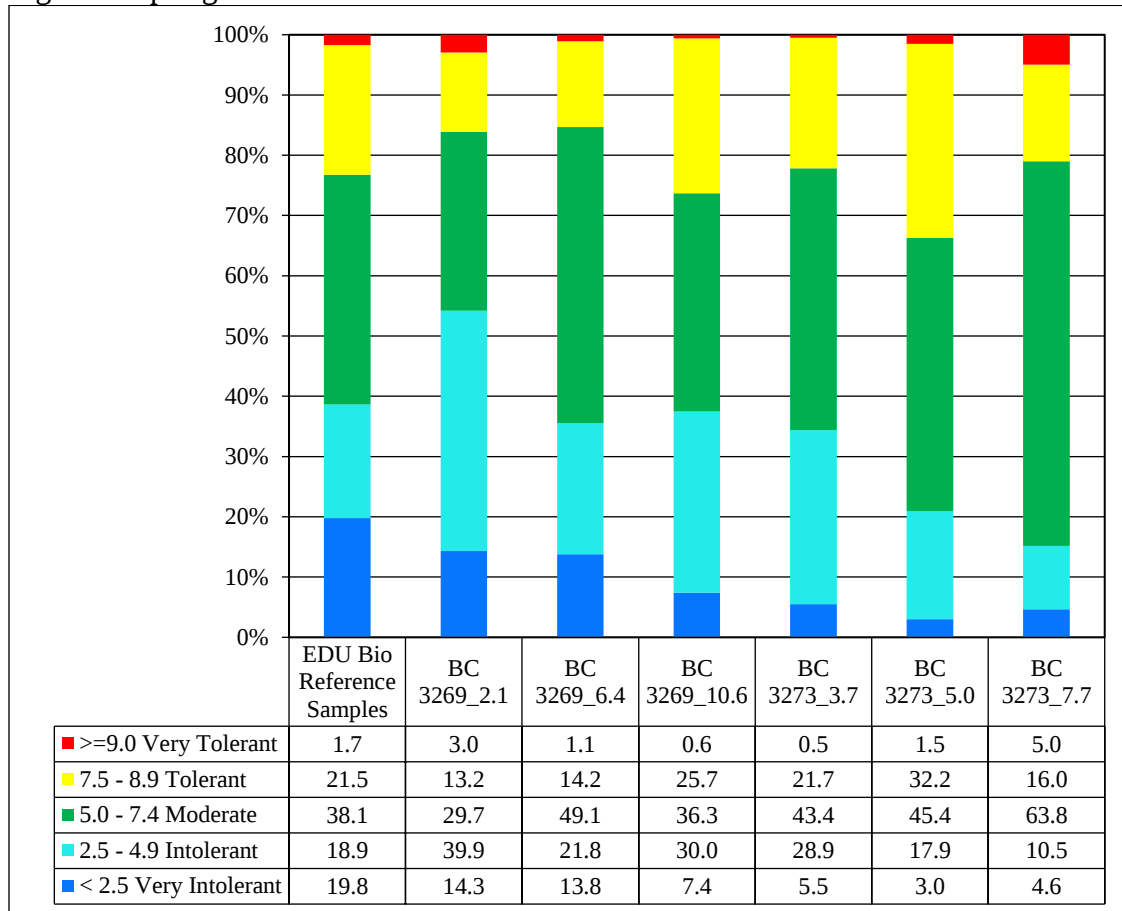
Top ten families in bold.

Figure 6. Spring 2021 Percent of Taxa by Functional Feeding Group



* “Other” includes parasites, macrophyte piercers, and taxa with no identified FFG

Figure 7. Spring 2021 Percent Sensitive Taxa



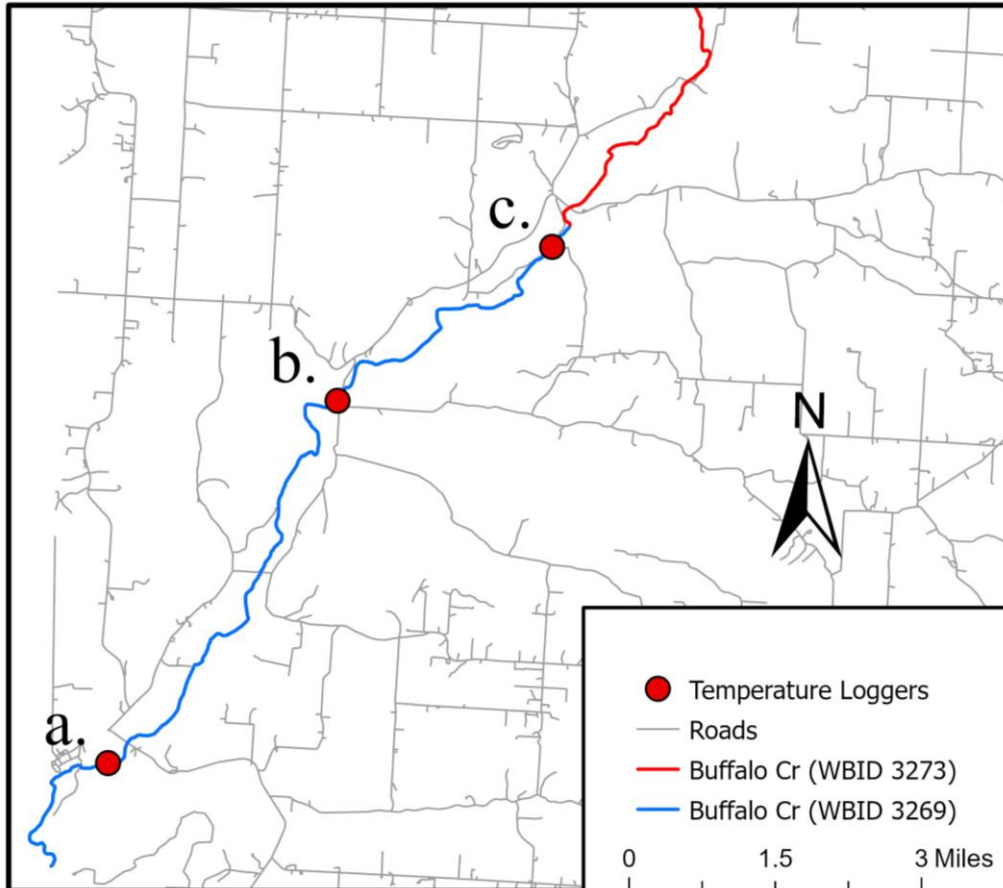
3.4.2 Investigation of Stream Temperature Class Designation

The Buffalo Creek sample reach is divided into two separate WBIDs with different temperature regime classifications (MoDNR 2018f). The section downstream of the Sugar Fork confluence (WBID 3269) is classified as cold-water, and the upper section (WBID 3273) is classified as a warm-water temperature regime (Figure 8). From field observations and temperature measurements (Table 3 and 4), Buffalo Creek WBID 3269 temperature exceeded cold-water classification standards. The Missouri WQS defines a cold-water stream as “[w]aters in which naturally-occurring water quality and habitat conditions allow the maintenance of a wide variety of cold-water biota. These waters can support a naturally reproducing or stocked trout fishery and populations of other cold-water species” (MoDNR 2018f). The WQS go on to state for cold-water habitats beyond the mixing zone of contaminant sources, “[w]ater contaminant sources shall not cause or contribute to temperatures above sixty-eight degrees Fahrenheit (68 °F) or twenty degrees Celsius (20 °C)” (MoDNR 2018f). To explore Buffalo Creek’s temperature classification beyond *in situ* field measurements, three temperature loggers were deployed in the cold-water section in accordance with standard operating procedures (Figure 9, MoDNR 2018e). Loggers were placed in deep, shaded pools to minimize diel temperature swings and remained in the field from July 25, 2022, to August 10, 2022 (Figure 9).

As the primary model species mentioned in the WQS (MoDNR 2018f), the Rainbow Trout’s (*Oncorhynchus mykiss*) thermal physiology is useful in designating cold-water habitat throughout the state. The thermal optimum of an organism is the ideal temperature range to promote growth and reproduction to maximize fitness. Rainbow Trout thermal optima were described by Piper et al. (1982) to be between 0.5 to 15.6 °C, and Molony (2001) measured preferred optimal physiological performance to be between 5 to 20°C. As a cold-water species, the Rainbow Trout is particularly vulnerable to increases in temperature. Temperatures outside the optima can cause reductions in juvenile growth rate, egg survival rate, and resistance to mortality from diseases (Nelitz et al. 2007).

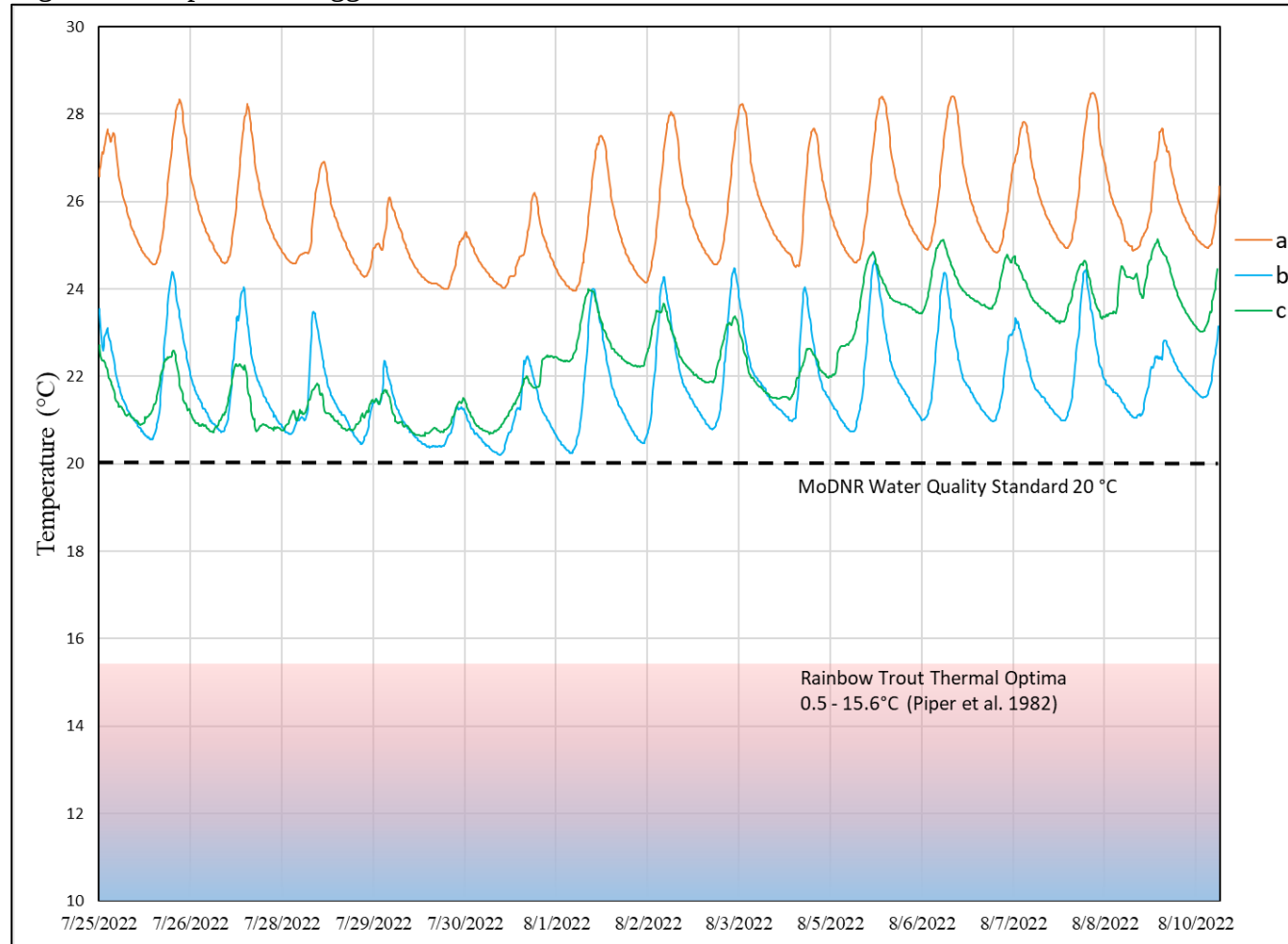
All data logger temperature readings surpassed the upper thermal optimum of the Rainbow Trout (Piper et al. 1982, Figure 9). Buffalo Creek WBID 3269 lacks the thermal regime necessary for ideal growth and reproduction to permanently sustain populations of Rainbow Trout. Based on these findings, Buffalo Creek WBID 3269 macroinvertebrate samples were scored using warm-water biological criteria for wadeable streams.

Figure 8. Location of Temperature Loggers on Buffalo Creek



a - below 3269/2.1; b - above 3269/6.4; c - below 3269/10.6

Figure 9. Temperature Logger Data from Buffalo Creek



a - below 3269/2.1; b - above 3269/6.4; c - below 3269/10.6

3.4.3 Macroinvertebrate Stream Condition Index (MSCI) Scores

All Buffalo Creek stations sampled during the fall 2019 field season attained fully supporting MSCI scores when using Ozark/Neosho EDU warm water biological criteria (Table 8). Downstream stations in WBID 3269 had slightly higher MSCI scores than stations in WBID 3273 (Table 8). During the spring 2021 field season, Buffalo Creek stations 3269/2.1 and 3269/6.4 had fully supporting MSCI scores (Table 9). All other stations had partially supporting scores in spring 2021 (Table 9).

Table 7. Fall 2019 Buffalo Creek Riffle/Pool Metric Values and Scores Using Ozark/Neosho Warm-Water Biological Criteria

Metrics	TR	EPTT	BI	SDI	MSCI	Support
BC 3269/2.1	85 (5)	25 (5)	5.5 (3)	3.34 (5)	18	F
BC 3269/6.4	82 (5)	27 (5)	5.7 (3)	3.37 (5)	18	F
BC 3269/10.6	80 (5)	24 (3)	5.4 (5)	3.40 (5)	18	F
BC 3273/3.7	78 (5)	22 (3)	5.7 (3)	3.38 (5)	16	F
BC 3273/5.0	72 (3)	27 (5)	5.8 (3)	3.38 (5)	16	F
BC 3273/7.7	77 (3)	27 (5)	6.1 (3)	3.13 (5)	16	F
Metric Score=5	> 77	> 24	< 5.5	> 2.97	20-16	Full
Metric Score=3	77 - 39	24 - 12	5.5 - 7.7	2.76 - 1.49	14-10	Partial
Metric Score=1	< 39	< 12	> 7.7	< 1.49	8 - 4	Non

MSCI Scoring Table (in light gray) developed from BIOREF samples ($n = 10$). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; numbers in parentheses indicate individual metric scores.

Table 8. Spring 2021 Buffalo Creek Riffle/Pool Metric Values and Scores Using Ozark/Neosho Warm-Water Biological Criteria

Metrics	TR	EPTT	BI	SDI	MSCI	Support
BC 3269/2.1	83 (5)	33 (5)	4.9 (5)	3.41 (5)	20	F
BC 3269/6.4	90 (5)	30 (5)	5.2 (5)	3.35 (5)	20	F
BC 3269/10.6	68 (3)	26 (3)	5.4 (3)	2.94 (3)	12	P
BC 3273/3.7	65 (3)	19 (3)	5.7 (3)	2.59 (3)	12	P
BC 3273/5.0	75 (5)	22 (3)	6.2 (3)	2.80 (3)	14	P
BC 3273/7.7	76 (5)	21 (3)	6.1 (3)	2.72 (3)	14	P
Metric Score=5	> 72	> 27	< 5.3	> 3.01	20-16	Full
Metric Score=3	72 - 36	27 - 13	5.3 - 7.7	3.01 - 1.51	14-10	Partial
Metric Score=1	< 36	< 13	> 7.7	< 1.51	8 - 4	Non

MSCI Scoring Table (in light gray) developed from BIOREF samples ($n = 14$). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; numbers in parentheses indicate individual metric scores.

3.5 Duplicate Sample Results

A duplicate physicochemical sample was collected at Buffalo Creek station 3273/3.7 during fall 2019 and at Buffalo Creek station 3273/7.7 during spring 2021. The duplicate sample difference criteria for the physicochemical parameters are specified in the Fiscal Year 2019 Quality Assurance Project Plan (MoDNR 2019b).

In fall 2019, turbidity and nitrate plus nitrite-nitrogen at Buffalo Creek station 3273/3.7 exceeded the duplicate relative percent difference criteria of 20 percent (Table 3). This may have occurred because both parameters were present in very low concentrations, and small absolute differences yielded relative percent difference values that exceeded 20 percent. The spring 2021 sample collected at Buffalo Creek station 3273/7.7 had no exceedances.

4.0 Discussion

4.1 Land Use

Buffalo Creek originates in Neosho, Missouri, and is located in the northern portion of the Ozark/Neosho EDU. Land use is primarily deciduous forests and hay/pasture fields containing little developed area (Table 1), with most sample sites located in sparsely populated areas (Figure 3). Sites located downstream had a higher percentage of deciduous forest compared to upstream stations, and upstream stations had higher percentages of urban development and hay/pasture fields (Figure 3, Table 1).

Land use directly influences local habitat and biological diversity of streams, specifically nonpoint pollution from agriculture and pasture (Allan 2004). In many upstream areas along Buffalo Creek, cattle had unrestricted stream access, which may increase bacteria concentrations (e.g. *E. coli*), total nitrogen, total phosphorus, total suspended sediments, and turbidity (Davies-Colley et al. 2004; James et al. 2007; Vidon et al. 2008). Introduced sedimentation in the stream channel may lead to a reduction in benthic stream species as interstitial habitat is reduced (Allan 2004). Nutrient enrichment from land use may increase algae growth and consequently decrease dissolved oxygen (Allan 2004), resulting in more tolerant taxa occupying the stream (Lenat and Crawford 1994).

4.2 Stream Habitat

Instream habitat and surrounding catchment variables influence aquatic community composition (Wang et al. 2007, Burdon et al. 2013). All stations contained suitable epifaunal substrate for invertebrates with acceptable amounts of sediment deposition and high-quality riffle habitat. Low vegetative protection scores can be attributed to low seasonal flows and dry weather conditions, leaving many of the streambanks barren. Insufficient riparian zone width at stations 3273/5.0 and 3273/7.7 coupled with reduced vegetative protection may reduce the streambank stability at those sites, as root reinforcement improves streambank stability (Easson and Yarbrough, 2002). Wider riparian zones help buffer and sustain aquatic organisms by filtering sediment and nutrients, especially in a watershed with high agricultural use (Lind et al. 2019).

4.3 Physicochemical Analysis

No Missouri WQS were violated at Buffalo Creek during fall 2019 and spring 2021 sampling (MoDNR 2018f). Although there are records of past lead, iron, and zinc mining activities in the watershed, there were no WQS violations for dissolved metals in Buffalo Creek samples. In fall 2019, all Buffalo Creek stations had total nitrogen concentrations above the Elk River Drainage TMDL target values (MoDNR 2004), and total phosphorus levels were above the target at stations 3273/5.0 and 3273/7.7. In spring 2021, total nitrogen concentrations exceeded the TMDL target at all stations, but all total phosphorus levels were below the target.

Using EPA's nutrient recommendations for streams and rivers (USEPA 2000), Buffalo Creek fall 2019 stations 3273/3.7, 3273/5.0, and 3273/7.7 exceeded the recommended

total phosphorus concentration, and all stations exceeded the recommended nitrite+nitrate and total nitrogen concentrations (Table 3). During spring 2021 sampling, all Buffalo Creek stations exceeded EPA's recommend values for nitrite+nitrate, total phosphorus, and total nitrogen (Table 4). High levels of nutrients can result in degraded aquatic communities (Dodds et al. 2009, Waite and Van Metre 2017, Wang et al. 2007). Excessive nutrients have been identified as a major reason why water quality objectives, such as support of aquatic life, fail (USEPA 2000). Additionally, all stations but 3269/10.6 exceed EPA's recommend value for turbidity during spring 2021 sampling (Table 4). Elevated, sustained values of turbidity and sedimentation harm aquatic ecosystems by reducing periphyton growth and phytoplankton productivity (Henley et al. 2000). Organisms such as zooplankton, insects, freshwater mollusks, and fish are adversely affected by the resulting decline of primary production (Henley et al. 2000).

4.4 Biological Assessment and Macroinvertebrate Community Composition

The thermal regime of Buffalo Creek's lower sample reach (WBID 3269) is currently classified as cold-water (MoDNR 2018f). Field observation and temperature readings from data loggers suggest that the lower reach is more consistent with a warm-water temperature regime. This is apparent when data logger temperature records are compared to WQS cold-water model species' (i.e. Rainbow Trout) thermal physiology (MoDNR 2018f). Using this justification, WBID 3269 was scored using warm-water biological criteria for the assessment.

During the fall 2019 field season, all Buffalo Creek stations had MSCI scores that were fully supporting of the protection of warm-water habitat designated use. Fall samples upstream in the watershed had slightly lower scores but still qualified as fully supporting. Over a year later, in spring 2021, stations 3269/2.1 and 3269/6.4 received the highest possible MSCI scores. The remaining stations upstream received partially supporting MSCI scores in spring. Most of the upstream four sites had declines in TR, EPTT, and SDI from fall to spring. The two farthest downstream stations mostly had increases in these metrics, and any decreases were insufficient to result in suboptimal individual metric scores. Stations 3269/10.6 and 3273/3.7 may have been affected by construction at the Gazelle Drive crossing, directly above station 3273/3.7. Buffalo Creek is categorized as a class P stream, which maintains permanent flow even in drought periods (MoDNR 2018f). Several visits to Buffalo Creek, however, revealed that there is a large section of WBID 3273 above station 3269/10.6 that periodically goes dry and appears to be intermittent. Station 3269/10.6 MSCI scores may be reduced due to the seasonal drying of Buffalo Creek directly above the Sugar Fork confluence.

Stream habitat generally was worse among upstream stations (i.e. WBID 3273) as riparian zone width and streambank stability declined (Table 2). These habitat factors appear to influence macroinvertebrate community compositions. In fall 2019, upstream stations had more tolerant macroinvertebrate taxa compared to downstream stations (Figure 5). Despite the slight differences in tolerance, fall 2019 stations generally had

higher relative abundance of EPTT compared to BIOREF stations in the same EDU (Table 6 and 7). Spring 2021 samples experienced a decrease of tolerant taxa in the four upper stations on Buffalo Creek (Figure 7). The number of EPTT and relative abundance of EPTT reflect this shift in upper Buffalo Creek (Table 7). As more intolerant taxa declined in upper Buffalo Creek, tolerant species abundance tended to increase in these stations. For example, BIOREF stations in the Ozark/Neosho EDU have a relative abundance of 23.01% chironomids, which all Buffalo Creek spring 2021 stations exceeded (Table 7).

Functional feeding group data demonstrated a general reduction of scrapers and an increase in shredders and gatherer-collectors from fall 2019 to spring 2021. Because FFGs respond to anthropogenic inputs, stressed aquatic conditions are often manifested in FFG categories. Specialist FFG categories have specific feeding needs that may be limited in impaired systems, whereas generalist FFGs are thought to be more tolerant due to their ability to use a wider array of available food resources. Generalist categories, such as gatherer-collectors and filterer-collectors, increase in response to increased pollution, or disturbances, whereas specialists such as scrapers decrease (Barbour et al. 1999; Poulton et al. 2015).

Buffalo Creek originates in Neosho, Missouri, with one WWTP outfall and several other facilities with point source discharges to the stream. Urban areas and WWTPs often contribute to declines in aquatic communities and biotic integrity (Dyer and Wang 2002). Runoff from impervious surfaces and point source discharges can introduce contaminants and excess nutrients into waterways (Carpenter et al. 1998), causing taxa richness declines in aquatic communities (Paul and Meyer 2001).

5.0 Conclusions

Pastures used for livestock grazing are common streamside land uses in the Buffalo Creek watershed. Although there are large patches of forest adjoining the creek, much of the study reach has only narrow bands of trees in the riparian corridor, as well as areas where there are none. Anthropogenic activities surrounding Buffalo Creek have led to riparian habitat degradation and streambank instability, affecting instream habitat and aquatic life. Despite these factors, the downstream stations attained fully supporting MSCI scores in fall 2019 and spring 2021. No Missouri WQS were violated; however, some nutrient concentrations were slightly higher than Elk River TMDL target values and EPA's recommended values. In spring 2021, there were several stations in the middle and upper reaches that scored as only partially supporting.

Deficiencies in stream habitat can have a profound effect on aquatic organisms. Although macroinvertebrate densities can remain unchanged, EPTT representation in samples are highly correlated with habitat assessment scores (Mažeika et al. 2004). Upper reaches of Buffalo Creek generally had deeply incised streambanks with little to no riparian zone coverage. Subsequently, there is little buffer to filter sediments and nutrients from overland flows at the upstream Buffalo Creek stations. Aquatic EPTT occurrence is connected to their ability to capitalize on food resources located in a stream's habitat (Wallace and Webster 1996). Increased sediment load may have negatively influenced taxa richness, density, and traits of EPTT macroinvertebrates in upper Buffalo Creek (Akamagwuna et al. 2019, Zweig and Rabeni 2001). Habitat factors coupled with heavy cattle pasture land use may have reduced EPTT abundance in upper Buffalo Creek stations in spring 2021.

6.0 References Cited

- Akamagwuna, F.C., P.K. Mensah, C.F. Nnadozie, and O.N. Odume. 2019. Trait-based responses of Ephemeroptera, Plecoptera, and Trichoptera to sediment stress in the Tsitsa River and its tributaries; Eastern Cape, South Africa.
- Allan, J.D. 2004. Landscapes and riverscapes: the influence of land use on stream ecosystems. *Annual review of ecology, evolution, and systematics* 257-284.
- Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers-Periphyton, Benthic Macroinvertebrates, and Fish. 2nd Edition, EPA 841/B-99/002, USEPA, Washington DC.
- Burdon, F.J., A.R. McIntosh, and J.S. Harding. 2013. Habitat loss drives threshold response of benthic invertebrate communities to deposited sediment in agricultural streams. *Ecological Applications* 23(5): 1036-1047.
- Carpenter, S.R., N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley, and V.H. Smith. 1998. Nonpoint pollution of surface waters with phosphorus and nitrogen. *Ecological Applications* 8: 559-568.
- Chapman, S.S., J.M. Omernik, G.E. Griffith, W.A. Schroeder, T.A. Nigh, and T.F. Wilton. 2002. Ecoregions of Iowa and Missouri (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,800,000).
- Davies-Colley, R.J., J.W. Nagels, R.A. Smith, R.G. Young, and C.J. Phillips. 2004. Water quality impact of a dairy cow herd crossing a stream. *New Zealand Journal of Marine and Freshwater Research* 38(4): 569-576.
- Dewitz, J. 2021. National Land Cover Database (NLCD) 2019 Products [Data set]. U.S. Geological Survey.
- Dodds, W.K., W.W. Bouska, J.L. Eitzmann, T.J. Pilger, K.L. Pitts, A.J. Riley, J.T. Schloesser, and D.J. Thornbrugh. 2009. Eutrophication of US freshwaters: analysis of potential economic damages. *Environmental Science and Technology* 43(1): 12-19.
- Doisy, K.E., C.F. Rabeni, M.D. Combes, and R.J. Sarver. 2008. Biological criteria for stream fish communities of Missouri. Final report submitted to the Environmental Protection Agency, Region 7, Kansas City, Kansas 66101. Funded by EPA-R7WWPD-05-005, Grant #CP 98769301. 84pp.

- Dyer, S.D. and X. Wang. 2002. A Comparison of Stream Biological Responses to Discharges from Wastewater Treatment Plants in High and Low Population Density Areas. *Environmental Toxicology and Chemistry* 21: 1065-1075.
- Easson, G.L. and D. Yarbrough. 2002. The effects of riparian vegetation on bank stability. *Environmental and Engineering Geoscience* 8(4): 247-260.
- Henley, W.F., M.A. Patterson, R.J. Neves, and A.D. Lemly. 2000. Effects of sedimentation and turbidity on lotic food webs: a concise review for natural resource managers. *Reviews in Fisheries Science* 8(2): 125-139.
- James, E., P. Kleinman, T. Veith, R. Stedman, and A. Sharpley. 2007. Phosphorus contributions from pastured dairy cattle to streams of the Cannonsville watershed, New York. *Journal of Soil and Water Conservation* 62(1): 40-47.
- Lenat, D.R., and J.K. Crawford. 1994. Effects of land use on water quality and aquatic biota of three North Carolina Piedmont streams. *Hydrobiologia* 294:185-199.
- Lind, L., E.M. Hasselquist, and H. Laudon. 2019. Towards ecologically functional riparian zones: a meta-analysis to develop guidelines for protecting ecosystem function and biodiversity in agricultural landscapes. *Environmental Management* 249: 109391.
- Mažeika, S., P. Sullivan, M.C. Watzin, W.C. Hession. 2004. Understanding stream geomorphic state in relation to ecological integrity: evidence using habitat assessments and macroinvertebrates. *Environmental Management* 34:669-83.
- MoDNR. 2004. Total Maximum Daily Load for The Elk River Basin, McDonald, Barry and Newton Counties, Missouri. Water Pollution Control Program, P.O. Box 176, Jefferson City, Missouri. 47 pp.
- MoDNR. 2016. Standard Operating Procedure MDNR-ESP-213. Quality Control Procedures for Checking Water Quality Field Instruments. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 13pp.
- MoDNR. 2018a. Standard Operating Procedure MDNR-ESP-012. Analysis of Turbidity Using the Hach 2100P and 2100Q Portable Turbidimeter. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 13 pp.

MoDNR. 2018b. Standard Operating Procedure MDNR-ESP-100. Field Analysis of Water Samples for pH. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 8 pp.

MoDNR. 2018c. Standard Operating Procedure MDNR-ESP-101. Field Measurement of Water Temperature. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 4 pp.

MoDNR. 2018d. Standard Operating Procedure MDNR-ESP-102. Field Analysis of Specific Conductance in Water. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 9 pp.

MoDNR. 2018e. Standard Operating Procedure MDNR-ESP-104. Continuous Monitoring of Water Quality using a Dissolved Oxygen, Specific Conductance, PH, Turbidity, Rhodamine Dye, and Temperature Data Logger. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 18 pp.

MoDNR. 2018f. Title 10. Rules of Department of Natural Resources Division 20-Clean Water Commission, Chapter 7-Water Quality. 10 CSR 20-7.031 Water Quality Standards. pp. 11-131.

MoDNR. 2019a. Methodology for the Development of the 2020 Section 303 (d) List in Missouri, Final July 7, 2019. Prepared by the Missouri Department of Natural Resources, Division of Environmental Quality, Water Protection Program, P.O. Box 176, Jefferson City, Missouri 65102. 63 pp.

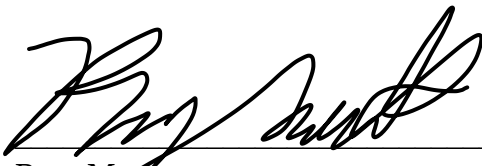
MoDNR. 2019b. Quality Assurance Project Plan for Biological Assessment, LDPR Code FEBIO, FETSW, & FECLC. State Fiscal Year 2020. Prepared by the Missouri Department of Natural Resources, Division of Environmental Quality, Water Protection Program, P.O. Box 176, Jefferson City, Missouri 65102. 23 pp.

MoDNR. 2019c. Semi-Quantitative Macroinvertebrate Stream Bioassessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 29 pp.

MoDNR. 2019d. Standard Operating Procedure MDNR-ESP-001. Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 29 pp.

- MoDNR. 2019e. Standard Operating Procedure MDNR-ESP-103. Field Analysis of Dissolved Oxygen Using Meters. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 11 pp.
- MoDNR. 2019f. Standard Operating Procedure MDNR-ESP-113. Flow Measurements in Open Channels. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 16 pp.
- MoDNR. 2019g. Standard Operating Procedure MDNR-ESP-209. Taxonomic Levels for Macroinvertebrate Identifications. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 40 pp.
- MoDNR. 2019h. Standard Operating Procedure MDNR-ESP-210. Quality Assurance/Quality Control for Environmental Data Collection. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 13 pp.
- MoDNR. 2019i. Standard Operating Procedure MDNR-ESP-214. Quality Control Procedures for Data Processing. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 7 pp.
- MoDNR. 2019j. Stream Habitat Assessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 40 pp.
- Molony, B. 2001. Environmental requirements and tolerances of Rainbow trout (*Oncorhynchus mykiss*) and Brown trout (*Salmo trutta*) with special reference to Western Australia: A review. Fish Research Report West Australia 130.
- Nelitz, M.A., E.A. MacIsaac, R.M. Peterman. 2007. A science-based approach for identifying temperature-sensitive streams for Rainbow Trout. North American Journal of Fisheries Management 27: 405-424.
- Paul, M.J., and Meyer, J.L. 2001. Streams in the urban landscape. Annual Review of Ecology and Systematics 32:333–365.
- Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard. 1982. Fish hatchery management. U.S. Department of the Interior, Fish and Wildlife Service.

- Vidon, P., M.A. Campbell, and M. Gray. 2008. Unrestricted cattle access to streams and water quality in till landscape of the Midwest. *Agricultural Water Management* 95(3): 322-330.
- Waite, I.R. and P.C. Van Metre. 2017. Multistressor predictive models of invertebrate condition in the Corn Belt, USA. *Freshwater Science* 36(4): 901-914.
- Wallace, J.B. and J.R. Webster. 1996. The role of macroinvertebrates in stream ecosystem function. *Annual Review of Entomology* 41: 115-139.
- Wang, L., D.M. Robertson, and P.J. Garrison. 2007. Linkages between nutrients and assemblages of macroinvertebrates and fish in wadeable streams: Implication to nutrient criteria development. *Environmental Management* 39: 194-212.
- United States Environmental Protection Agency (USEPA). 2000. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria, Rivers and Streams in Nutrient Ecoregion XI. United States Environmental Protection Agency, Office of Water, Washington, D.C., EPA-822-B-00-020. 99 pp.
- Zweig, L.D. and C.F. Rabeni. 2001. Biomonitoring for deposited sediment using benthic invertebrates: a test on 4 Missouri streams. *Journal of the North American Benthological Society* 20: 643-657.

Submitted by:  8/23/2024
Rory Mott
Water Quality Biologist
Water Quality Monitoring Section
Environmental Services Program
Date

Technical Review by:  8/23/2024
Dave Michaelson
Environmental Program Supervisor
Water Quality Monitoring Section
Environmental Services Program
Date

Approved by:  8/26/2024
Scott Robinett
Environmental Program Manager
Water Quality Monitoring Section
Environmental Services Program
Date

SR:rm

c: Robert Voss, WPP
Tanya Turner, SWRO

Appendix A

Macroinvertebrate Database Bench Sheet Report Fall 2019 and Spring 2021

Buffalo Creek, McDonald and Newton County Missouri

Grouped by Season and Station

Fall 2019 Macroinvertebrate Bench Sheet Report			
Oct 01, 2019 Buffalo Creek - 0.1 mi. bl. Hwy 76 [3269_2.1] - 19064			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	12	2	
AMPHIPODA			
Hyaella azteca			58
Stygobromus	1		
ARHYNCHOBELLELLIDA			
Erpobdellidae	*	*	
BASOMMATOPHORA			
Helisoma		1	
Physella			2
COLEOPTERA			
Dubiraphia			5
Ectopria nervosa	2	17	
Lutrochus	1		
Microcyloepus pusillus	1		
Optioservus sandersoni	5		
Psephenus herricki	16	5	
Scirtidae			9
Stenelmis	19	110	7
DECAPODA			
Faxonius neglectus			*
DIPTERA			
Ablabesmyia			3
Cardiocladius	2		

Chironomidae	1		1
Chironomus		1	
Cricotopus/Orthocladius			12
Dicortendipes	1	7	17
Forcipomyiinae		1	2
Hemerodromia	3		
Hexatoma	1		
Labrundinia			2
Microtendipes	4		
Myxosargus			1
Nemotelus			1
Paratanytarsus			1
Paratendipes		2	
Phaenopsectra		1	1
Polypedilum fallax grp			1
Polypedilum flavum	20		3
Polypedilum illinoense grp	1		2
Rheotanytarsus	12		8
Simulium	1		
Stempellinella		4	2
Stenochironomus			3
Synorthocladius		1	2
Tanytarsus	2	3	3
Thienemanniella	3	1	1
Thienemannimyia grp		4	11
EPHEMEROPTERA			
Acerpenna	1	9	1
Baetis	269	5	

Caenis anceps	1		
Caenis latipennis			3
Centroptilum			1
Choroterpes		5	
Isonychia bicolor	5		
Leucrocota	10	4	
Proclleon		2	1
Stenacron		1	
Stenonema bednariki	71	2	
Stenonema femoratum		25	3
Stenonema mediopunctatum	19	5	
Tricorythodes	2	8	7
ISOPODA			
Caecidotea (Blind & Unpigmented)	2	10	
Lirceus		3	
LUMBRICINA			
Lumbricina	12	10	
LUMBRICULIDA			
Lumbriculidae		4	
MEGALOPTERA			
Corydalus	12		
Sialis		*	
NEOTAENIOGLOSSA			
Elimia	13	2	14
ODONATA			
Argia	2	6	
Basiaeschna janata			*
Calopteryx			7
Enallagma			11
Gomphidae	1		1
Hetaerina			3
Macromia			4
Nasiaeschna pentacantha			1
Stylogomphus albistylus			*
PLECOPTERA			
Agnetina flavescens	31		
Neoperla	14	2	1

TRICHOPTERA			
Cheumatopsyche	36		
Chimarra	15		
Helicopsyche	1		
Hydropsyche morosa grp	1		
Hydroptila			4
Marilia	34	7	
Oecetis			72
Polycentropus		1	
Trienodes			25
TRICLADIDA			
Planariidae	5	43	
TUBIFICIDA			
Enchytraeidae	1		

Oct 01, 2019 Buffalo Creek - 0.2 mi. ab. Stogdon Creek [3269_6.4] - 19065			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	4	4	
AMPHIPODA			
Gammarus	4	1	4
Hyaella azteca			88
BASOMMATOPHORA			
Menetus		1	
Physella			3
COLEOPTERA			
Berosus		1	
Dubiraphia		1	7
Ectopria nervosa	1	5	
Optioservus sandersoni	23	3	1
Psephenus herricki	71	27	*
Scirtidae			14
Stenelmis	42	134	1
DECAPODA			
Faxonius neglectus	*		2
DIPTERA			

Ablabesmyia			1
Ceratopogoninae	1		
Chironomidae	1	2	
Chironomus		2	
Cricotopus bicinctus			2
Cricotopus/Orthocladius			2
Dicrotendipes		3	11
Hemerodromia			1
Hexatoma	*		
Labrundinia			5
Microtendipes	7	8	
Paratanytarsus	1		20
Polypedilum fallax grp			1
Polypedilum flavum	12	1	4
Polypedilum illinoense grp			4
Pseudolimnophila		1	
Pseudosmittia			1
Rheotanytarsus	10		26
Simulium	1		
Stempellinella		2	
Synorthocladius	2	3	1
Tabanus	4		
Tanytarsus	3	7	20
Thienemanniella	6	4	2
Thienemannimyia grp	1	2	15
EPHEMEROPTERA			
Acentrella	4		
Acerpenna	4	6	14
Baetis	172	3	2
Caenis latipennis	6	7	1
Choroterpes		3	
Dipheter	3		2
Isonychia bicolor	9		
Leptophlebiidae	1	4	1
Leucrocota	5	3	
Stenacron	4	4	1
Stenonema bednariki	8		

Stenonema femoratum	3	25	1
Stenonema mediopunctatum	15		
Stenonema pulchellum	4	2	3
Tricorythodes	3	2	
HEMIPTERA			
Microvelia			4
ISOPODA			
Caecidotea			2
Caecidotea (Blind & Unpigmented)	2	2	
Lirceus	5		
LUMBRICINA			
Lumbricina	3	2	
LUMBRICULIDA			
Lumbriculidae	1		
MEGALOPTERA			
Corydalus	7	1	1
NEOTAENIOGLOSSA			
Elimia	4	1	
ODONATA			
Argia	20	6	3
Calopteryx			11
Enallagma			9
Gomphidae	3	3	
Macromia			1
Stylogomphus albistylus		1	
PLECOPTERA			
Acroneuria	3	2	
Agnetina flavescens	8	3	
Leuctra	1		
TRICHOPTERA			
Cheumatopsyche	166		5
Chimarra	8		
Helicopsyche	1		
Hydropsyche morosa grp	7		
Limnephilidae			1
Marilia	25	11	1
Oecetis			24

Polycentropus	2	1	
Trienodes			18
TRICLADIDA			
Planariidae	34	4	2
TUBIFICIDA			
Limnodrilus hoffmeisteri		1	
VENEROIDA			
Corbicula		1	

Oct 02, 2019 Buffalo Creek - bl. Sugar Fork [3269_10.6] - 19066			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	6	4	2
AMPHIPODA			
Gammarus	9		39
Hyaella azteca			13
BASOMMATOPHORA			
Ancylidae	2		
Physella	2		
BRANCHIOBELLELLIDA			
Branchiobdellida	1		
COLEOPTERA			
Cymbiodyta	1		
Dubiraphia		3	5
Microcyllopus pusillus			4
Optioservus sandersoni	44	6	1
Psephenus herricki	91	40	2
Scirtidae			10
Stenelmis	57	53	4
DECAPODA			
Faxonius neglectus	1	*	*
DIPTERA			
Ablabesmyia	2	1	1
Chironomidae	2	1	2
Chironomus		10	
Corynoneura		1	

Cricotopus bicinctus		1	1
Cricotopus/Orthocladius	1	1	
Cryptochironomus		1	
Dicrotendipes	1	1	
Hemerodromia			1
Hexatoma	*		
Labrundinia			4
Microtendipes	2	4	
Paraphaenocladus		1	
Paratanytarsus		1	
Phaenopsectra		1	1
Polypedilum aviceps			1
Polypedilum flavum	27	1	1
Polypedilum illinoense grp			3
Polypedilum scalaenum grp		1	
Rheotanytarsus	3		16
Smittia			1
Stempellinella	4	4	
Stenochironomus			1
Synorthocladius			1
Tanytarsus	7	5	4
Thienemanniella	1		1
Thienemannimyia grp	4	2	4
Zavrelimyia		1	
EPHEMEROPTERA			
Acerpenna	42	2	17
Baetis	100		6
Caenis anceps	25	11	
Caenis latipennis	1	4	
Choroterpes		1	
Dipheter	7		3
Isonychia bicolor	2		
Leptophlebiidae	1	5	
Leucrocuta	22	1	
Procloeon			2
Stenacron	11	10	
Stenonema bednariki	1		

Stenonema femoratum	13	36	6
Stenonema pulchellum	5		
Tricorythodes		1	2
HEMIPTERA			
Microvelia			5
Trepobates			1
ISOPODA			
Caecidotea			56
Lirceus	22	15	37
LUMBRICINA			
Lumbricina	1	5	1
MEGALOPTERA			
Corydalus	*		
NEOTAENIOGLOSSA			
Elimia	25		2
ODONATA			
Calopteryx		1	8
Erythemis			1
Gomphidae	1		
Stylogomphus albistylus		3	*
PLECOPTERA			
Acronetia	*	1	
Agnetina capitata	7		
TRICHOPTERA			
Cheumatopsyche	42		10
Chimarra	4		
Helicopsyche	20	3	
Hydropsyche morosa grp	3		1
Polycentropus	1	3	
Psychomyia	1		
Triaenodes			1
TRICLADIDA			
Planariidae	37	6	
TUBIFICIDA			
Limnodrilus hoffmeisteri		1	
Tubificinae		2	

Oct 02, 2019 Buffalo Creek - 0.4 mi. ab. Rosebay Dr. [3273_3.7] - 19067			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	23	5	5
AMPHIPODA			
Crangonyx		1	
Gammarus			3
Hyalella azteca			47
Stygobromus	1		
BASOMMATOPHORA			
Physella	1		*
COLEOPTERA			
Dubiraphia			11
Neoporus			2
Ochthebius	3		
Optioservus sandersoni	22	5	
Psephenus herricki	69	29	9
Scirtidae			3
Stenelmis	21	70	14
DECAPODA			
Faxonius macrus	*		
Faxonius neglectus		1	5
DIPTERA			
Ablabesmyia	6		3
Chironomidae	2	1	
Chironomus			1
Corynoneura			1
Cricotopus bicinctus			2
Cricotopus/Orthocladius	1	1	4
Cryptochironomus	1		3
Dicrotendipes			3
Dolichopodidae		1	
Labrundinia			7
Microtendipes		4	
Natarsia			1
Parametriocnemus	1		

Paratanytarsus			1
Phaenopsectra		1	1
Polypedilum flavum	35	1	8
Polypedilum illinoense grp			1
Rheocricotopus	1		1
Rheotanytarsus	7		27
Simulium	5		4
Stempellinella	2	5	1
Stenochironomus			1
Tabanus	*		
Tanytarsus	5	7	17
Thienemanniella	2		7
Thienemannimyia grp	5		14
Tipula	1		1
EPHEMEROPTERA			
Acentrella	2		
Acerpenna	39		6
Baetis	61		5
Caenis anceps	6	8	1
Caenis latipennis		28	10
Choroterpes		5	
Heptageniidae	22	1	2
Isonychia bicolor	71		6
Leucrocuta	1		
Stenacron	13	17	
Stenonema bednariki	2		
Stenonema femoratum	14	99	7
Stenonema mediopunctatum	2		
Tricorythodes	2		1
HEMIPTERA			
Microvelia			4
ISOPODA			
Caecidotea	1	1	
Lirceus	4	2	55
LUMBRICINA			
Lumbricina		*	1
MEGALOPTERA			

Nigronia serricornis	*		
ODONATA			
Argia	2	4	2
Calopteryx			8
Gomphidae		1	1
Hagenius brevistylus		1	
Stylogomphus albistylus			2
PHARYNGOBDELLIDA			
Hirudinidae			*
PLECOPTERA			
Acronuria	*	*	*
Agnetina flavescens	6		
TRICHOPTERA			
Cheumatopsyche	103		9
Chimarra	5		
Helicopsyche	7	2	
Hydropsyche morosa grp	1		
Polycentropus	3	2	1
Triaenodes	1		3
TRICLADIDA			
Planariidae	34	4	10
TUBIFICIDA			
Limnodrilus hoffmeisteri			1
Tubificinae			4

Oct 02, 2019 Buffalo Creek - Queens Lace Rd. [3273_5.0] - 19068			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	17	8	
AMPHIPODA			
Crangonyx			1
Gammarus	6	2	61
Hyaella azteca			51
BASOMMATOPHORA			
Ancylidae	1		1
Menetus			4

BRANCHIOBELLELLIDA			
Branchiobdellida			3
COLEOPTERA			
Dubiraphia			1
Optioservus sandersoni	33	7	2
Psephenus herricki	68	32	1
Stenelmis	32	38	4
DECAPODA			
Faxonius neglectus	*		6
DIPTERA			
Ablabesmyia		15	
Cardiocladius	1		
Cricotopus/Orthocladius		2	1
Cryptochironomus	1		
Dasyheleinae	1		
Dicrotendipes	1	3	1
Hemerodromia	1		
Labrundinia			2
Micropsectra		1	1
Microtendipes	1	1	
Parametriocnemus	1		
Paratanytarsus			2
Phaenopsectra		1	
Polypedilum flavum	12	6	1
Polypedilum illinoense grp			1
Rheotanytarsus	10		9
Stempellinella	6	8	
Tabanus	*		
Tanytarsus	9	2	2
Thienemanniella	8	1	
Thienemannimyia grp	12	4	6
EPHEMEROPTERA			
Acentrella	1		
Acerpenna	29	4	5
Baetis	17		
Caenis anceps	37	22	1
Caenis latipennis		7	3

Eurylophella enoensis			1
Isonychia bicolor	25		1
Leptophlebiidae	13	3	5
Leucrocota	22	1	
Plauditus	1		
Proclonon			2
Stenacron	20	17	
Stenonema bednariki	5		
Stenonema femoratum	27	118	5
Tricorythodes	3		3
HEMIPTERA			
Microvelia			2
ISOPODA			
Caecidotea (Blind & Unpigmented)	4		
Lirceus	41	4	67
LUMBRICINA			
Lumbricina		1	
LUMBRICULIDA			
Lumbriculidae			1
MEGALOPTERA			
Corydalus	1		
ODONATA			
Argia	5	7	
Calopteryx			5
Gomphidae	9	2	1
Stylogomphus albistylus	1		
PLECOPTERA			
Acronuria	4	*	
Agnetina capitata	4		
Leuctra		1	
Neoperla	9	1	
TRICHOPTERA			
Cheumatopsyche	80		6
Chimarra	6		
Helicopsyche	5		1
Hydropsyche morosa grp	3		
Hydroptila			1

Oecetis			2
Polycentropus	3	6	2
Triaenodes			13
TRICLADIDA			
Planariidae	43	10	7
TUBIFICIDA			
Branchiura sowerbyi	3	2	

Oct 02, 2019 Buffalo Creek - 0.3 mi. bl. Hereford Rd. [3273_7.7] - 19069			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	4	27	2
AMPHIPODA			
Hyalella azteca		1	294
BASOMMATOPHORA			
Menetus		1	4
Physella	1	1	2
COLEOPTERA			
Dubiraphia			5
Enochrus	1		
Optioservus sandersoni	12	5	
Paracymus	1		
Psephenus herricki	30	40	2
Scirtidae			8
Stenelmis	6	41	4
Tropisternus			*
DECAPODA			
Faxonius macrus	*		
Faxonius neglectus			*
DIPTERA			
Ablabesmyia		3	1
Chironomus		1	
Corynoneura			1
Cricotopus/Orthocladius	1		
Cryptochironomus		2	
Dicrotendipes		8	

Hemerodromia	2		
Labrundinia			6
Microtendipes		1	1
Paratanytarsus			4
Paratendipes		1	
Polypedilum aviceps	15	1	
Polypedilum fallax grp			1
Polypedilum flavum	25		
Prosimulium	1		
Rheocricotopus	5		
Rheotanytarsus	11		2
Simulium	9		
Stempellinella		10	3
Tanytarsus	4	9	1
Thienemanniella	1		2
Thienemannimyia grp	3	4	7
Tipula	1	1	
Tribelos		1	
EPHEMEROPTERA			
Acentrella	5		
Acerpenna	3	1	
Baetis	64		
Caenis anceps	6	78	3
Caenis latipennis	1	67	16
Choroterpes		2	
Isonychia bicolor	55		
Leucrocuta	2		
Procloeon		1	
Stenacron	2	16	
Stenonema femoratum	1	48	15
Stenonema mediopunctatum	2		
Stenonema pulchellum	11	11	
Tricorythodes		1	1
HEMIPTERA			
Microvelia			2
Trepobates			1
ISOPODA			

Caecidotea (Blind & Unpigmented)		2	
Lirceus	6	2	8
LUMBRICINA			
Lumbricina	1	1	
MEGALOPTERA			
Corydalus	2	*	
ODONATA			
Argia		3	2
Enallagma			1
Gomphidae	1	1	
Hetaerina			1
Ischnura			1
PLECOPTERA			
Acroneuria	*		
Agnetina capitata	11		
Agnetina flavescens	1		
Leuctra	1		
Neoperla	2		
TRICHOPTERA			
Cheumatopsyche	177	1	
Chimarra	30	1	
Helicopsyche	4	6	1
Hydropsyche	1		
Hydropsyche morosa grp	16		
Polycentropus	1	2	2
Triaenodes			10
Wormaldia	2		
TRICLADIDA			
Planariidae	26	3	5

Spring 2021 Macroinvertebrate Bench Sheet Report			
Mar 08, 2021 Buffalo Creek - 0.1 mi. bl. Hwy 76 [3269_2.1] - 21000			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	6	4	
AMPHIPODA			
Hyaella azteca		2	27
BASOMMATOPHORA			
Physella	1	2	4
COLEOPTERA			
Dubiraphia			2
Ectopria nervosa	1	2	
Optioservus sandersoni		4	
Psephenus herricki	3	4	
Stenelmis	13	3	
DECAPODA			
Faxonius neglectus		*	*
DIPTERA			
Brillia	1		
Cardiocladius			1
Chironomidae		2	
Corynoneura	3	11	
Cricotopus bicinctus			3
Cricotopus/Orthocladius	21	59	60
Dicrotendipes		4	4
Eukiefferiella	13	3	9
Hemerodromia	1	1	
Hexatoma	1		
Labrundinia		1	
Microtendipes	1	2	
Orthocladius (Euorthocladius)	1		1
Parametriocnemus	9	1	
Paratanytarsus		2	4
Phaenopsectra		1	
Rheotanytarsus			16

Simulium	3		1
Stempellinella		2	1
Sympotthastia	9		
Synorthocladius	1	44	55
Tabanus	1	*	
Tanytarsus	1	18	5
Thienemanniella	1	1	8
Thienemannimyia grp	3	31	4
Tipula	*	*	
EPHEMEROPTERA			
Acentrella	97		11
Acerpenna	17	15	6
Anthopotamus	2		
Baetis	3		
Caenis latipennis	2	7	
Ephemerella invaria	11	4	9
Eurylophella bicolor		4	1
Isonychia bicolor	2		
Leptophlebia		9	3
Leucrocota		7	
Stenacron	25	30	
Stenonema bednariki	150	34	
Stenonema femoratum		45	
Stenonema mediopunctatum	6	6	
Stenonema pulchellum	6	6	1
Tricorythodes		1	
ISOPODA			
Caecidotea (Blind & Unpigmented)	8	1	
Lirceus	8	7	4
LUMBRICINA			
Lumbricina	29	*	
MEGALOPTERA			
Corydalus	*	*	
Sialis		*	
NEOTAENIOGLOSSA			
Elimia			6
ODONATA			

Argia		2	
Boyeria			*
Calopteryx			4
Enallagma			2
Gomphidae		1	
Hagenius brevistylus			*
Hetaerina			*
Stylogomphus sigmastylus		*	*
PLECOPTERA			
Acronuria		*	
Agnetina flavescens	36	8	
Chloroperlidae		2	
Helopicus nalatus	*		
Isoperla	4	4	
Neoperla	25	50	
Perlesta			5
Perlinella drymo		*	
Perlinella ephyre	5	1	
TRICHOPTERA			
Cheumatopsyche	11	3	*
Chimarra	7	3	1
Marilia	38	3	1
Mystacides		1	
Oecetis		1	4
Polycentropus	2	4	
Pycnopsyche		1	1
Triaenodes			1
TRICLADIDA			
Planariidae	32	11	

Mar 08, 2021 Buffalo Creek - 0.2 mi. ab. Stogdon Creek [3269_6.4] - 21001			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	53	9	2
AMPHIPODA			
Gammarus	4	12	1

Hyalella azteca		1	39
Stygobromus		2	
BASOMMATOPHORA			
Ancylidae		1	
Physella	2	3	1
COLEOPTERA			
Dubiraphia			7
Ectopria nervosa		2	
Optioservus sandersoni	8	4	
Psephenus herricki	2	3	
Stenelmis	2	18	
DECAPODA			
Faxonius neglectus	*		*
DIPTERA			
Antocha	1		
Atherix	*		
Chironomidae		1	
Clinocera	7	1	
Corynoneura		6	5
Cricotopus bicinctus		2	3
Cricotopus/Orthocladius	139	100	104
Cryptochironomus		1	
Dicrotendipes		6	6
Eukiefferiella	48	2	28
Hemerodromia	2	3	
Hexatoma		*	
Labrundinia			1
Micropsectra	9	16	2
Microtendipes		5	
Orthocladius (Euorthocladius)	5		
Paratanytarsus		2	2
Phaenopsectra		1	1
Polypedilum flavum	8		
Rheocricotopus	2		1
Rheotanytarsus	1	1	3
Stempellinella	1	6	
Sympotthastia	5	4	1

Synorthocladius	18	11	10
Tabanus	*		
Tanytarsus	12	6	3
Thienemanniella	2	1	4
Thienemannimyia grp	3	11	7
Zavrelimyia (Paramerina)		1	
EPHEMEROPTERA			
Acentrella	40		
Acerpenna	26	24	6
Anthopotamus	2		
Caenis latipennis			13
Dipheter	10		
Ephemerella invaria	3	4	
Eurylophella bicolor		1	
Isonychia bicolor	2		*
Leptophlebia		14	5
Leucrocota	4	7	
Stenacron	2	6	
Stenonema bednariki	12	14	
Stenonema femoratum		24	1
Stenonema mediopunctatum	13	4	
HEMIPTERA			
Microvelia			1
Ranatra fusca			*
ISOPODA			
Caecidotea (Blind & Unpigmented)		2	
Lirceus	12	15	6
LUMBRICINA			
Lumbricina		2	
LUMBRICULIDA			
Lumbriculidae	1	2	
MEGALOPTERA			
Corydalus	*		
NEOTAENIOGLOSSA			
Elimia	1	1	5
ODONATA			
Argia	1		1

Basiaeschna janata			*
Boyeria			1
Calopteryx			3
Enallagma			2
Gomphidae			1
Stylogomphus albistylus			*
PLECOPTERA			
Acronetia	9	1	
Amphinemura	8		3
Chloroperlidae	2	4	
Isoperla	5	*	*
Neoperla		7	
Perlesta	35	3	19
Perlinella drymo		*	*
Perlinella ephyre		2	
TRICHOPTERA			
Cheumatopsyche	17	1	*
Glossosomatidae	*		
Helicopsyche	18	3	*
Lepidostoma	2	1	
Marilia	15	4	
Oecetis	1		1
Polycentropus	1	3	
Pycnopsyche		*	1
TRICLADIDA			
Planariidae	22	17	2
TUBIFICIDA			
Limnodrilus hoffmeisteri		1	
Tubificinae			3
VENEROIDA			
Pisidiidae			2

Mar 08, 2021 Buffalo Creek - bl. Sugar Fork
 [3269_10.6] - 21002

* - large rare

ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	8	17	3

AMPHIPODA			
Gammarus	2	4	9
Hyalella azteca	1		10
ARHYNCHOBDSELLIDA			
Erpobdellidae	*		
BASOMMATOPHORA			
Physella	1		*
COLEOPTERA			
Dubiraphia			1
Optioservus sandersoni	67	8	5
Psephenus herricki	2	*	
Stenelmis	2	1	1
DECAPODA			
Faxonius neglectus	*	*	1
DIPTERA			
Chironomidae			
Clinocera	4		
Corynoneura	1	15	2
Cricotopus/Orthocladius	56	101	66
Cryptochironomus		1	
Dicrotendipes		5	4
Eukiefferiella	27	3	19
Micropsectra	2	2	2
Parametriocnemus	1		
Paratanytarsus			2
Paratendipes		2	
Polypedilum flavum	1		
Rheocricotopus	2	1	2
Rheotanytarsus		1	1
Simulium	1		
Stempellinella	3	6	1
Sympotthastia	3	10	5
Synorthocladius		2	3
Tabanus	*	*	
Tanytarsus	2	4	3
Thienemanniella			3
Thienemannimyia grp	1	17	7
Tipula	*	*	

EPHEMEROPTERA			
Acentrella	160		3
Acerpenna	3	13	8
Dipheter	8		
Ephemerella invaria	*		
Eurylophella bicolor		1	4
Leptophlebia	7	10	
Leucrocota	4	4	
Stenacron	4	16	1
Stenonema bednariki	3	2	
Stenonema femoratum	1	28	6
Stenonema mediopunctatum	1	2	1
ISOPODA			
Lirceus	69	30	94
LEPIDOPTERA			
Crambidae			1
LUMBRICINA			
Lumbricina	*	*	
MEGALOPTERA			
Corydalus	*		
Sialis		*	
NEOTAENIOGLOSSA			
Elimia			15
ODONATA			
Calopteryx			*
Stylogomphus sigmastylus		*	
PLECOPTERA			
Acroneuria		*	
Agnetina capitata	7	3	1
Amphinemura	1		2
Chloroperlidae	16	2	
Isoperla	6		
Leuctridae	10		
Perlesta		1	3
Perlinella drymo		*	
TRICHOPTERA			
Cheumatopsyche	4		2

Chimarra	1		
Helicopsyche	12	4	1
Ironoquia			2
Polycentropus		3	
Psychomyia	1		1
Pycnopsyche			4
TRICLADIDA			
Planariidae	30	5	3
TUBIFICIDA			
Tubificinae			1

Mar 08, 2021 Buffalo Creek - 0.4 mi. ab. Rosebay Dr. [3273_3.7] - 21003			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	9	17	1
AMPHIPODA			
Hyalella azteca			2
Stygobromus	1	3	1
BASOMMATOPHORA			
Physella	1		1
BRANCHIOBELLELLIDA			
Branchiobdellida			1
COLEOPTERA			
Optioservus sandersoni	3		
Psephenus herricki	*		
Stenelmis	1	10	1
DECAPODA			
Faxonius neglectus	*	*	*
DIPTERA			
Chironomidae		3	5
Clinocera	11	6	2
Corynoneura	1	29	6
Cricotopus bicinctus			2
Cricotopus/Orthocladius	135	210	85
Dicrotendipes		2	
Eukiefferiella	70	1	61

Hemerodromia	3		
Labrundinia			1
Micropsectra	1	2	2
Microtendipes		1	
Orthocladius (Euorthocladius)	8		3
Paratanytarsus		5	2
Polypedilum aviceps	1		
Polypedilum flavum	4		
Rheocricotopus	1	4	4
Rheotanytarsus			4
Simulium	1		4
Stempellinella	1		
Sympotthastia	18	1	34
Synorthocladius	1	5	
Tabanus	1	*	
Tanytarsus	2	8	2
Thienemanniella	3	1	1
Thienemannimyia grp	1	10	8
Tipula	*		1
EPHEMEROPTERA			
Acentrella	225		15
Acerpenna	11	1	1
Caenis latipennis	1		2
Ephemerella invaria	1		
Leptophlebia		2	2
Stenacron		2	
Stenonema femoratum	12	73	1
HEMIPTERA			
Microvelia			1
ISOPODA			
Caecidotea (Blind & Unpigmented)		8	3
Lirceus	58	76	71
LUMBRICINA			
Lumbricina	4	*	
LUMBRICULIDA			
Lumbriculidae	1	1	
MEGALOPTERA			

Corydalus	1		
ODONATA			
Argia			1
Calopteryx			1
Stylogomphus sigmastylus	*		
PLECOPTERA			
Acronuria	2	*	
Amphinemura	31		6
Chloroperlidae	10	6	
Hydroperla crosbyi	*		
Isoperla	26	*	*
Perlesta	23	2	4
Perlinella drymo		*	
Zealeuctra	1	1	
TRICHOPTERA			
Agapetus	1		
Cheumatopsyche	2		
Chimarra	1		
Polycentropus	2	*	
TRICLADIDA			
Planariidae	1		1
TUBIFICIDA			
Enchytraeidae			1

Mar 09, 2021 Buffalo Creek - Queens Lace Rd. [3273_5.0] - 21004			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	14	11	7
AMPHIPODA			
Crangonyx	1		
Gammarus	2	3	
Hyaella azteca			52
BASOMMATOPHORA			
Ancylidae		6	
Menetus			2
Physella		4	1

COLEOPTERA			
Dubiraphia			7
Dytiscidae			5
Gyrinus			1
Optioservus sandersoni	21	3	3
Psephenus herricki	4	1	
Scirtidae			1
Stenelmis		5	
DECAPODA			
Faxonius neglectus	*	1	
DIPTERA			
Ablabesmyia		1	
Clinocera	5	2	3
Corynoneura		7	
Cricotopus bicinctus			1
Cricotopus/Orthocladius	135	152	56
Dicrotendipes		2	8
Eukiefferiella	36		7
Hexatoma		*	
Micropsectra	1	3	4
Microtendipes		1	
Orthocladius (Euorthocladius)	4		
Parametriocnemus	1		1
Paratanytarsus		4	13
Paratendipes		3	
Phaenopsectra			1
Polypedilum aviceps	1		
Polypedilum scalaenum grp		1	
Rheocricotopus	3	1	2
Rheotanytarsus	1		2
Simulium	1		
Sympotthastia	24	5	23
Synorthocladius		2	
Tabanus	3		
Tanytarsus		5	2
Thienemanniella	1		
Thienemannimyia grp	2	7	19

EPHEMEROPTERA			
Acentrella	103		3
Acerpenna	6	5	7
Caenis latipennis		1	
Diphetor	4		
Isonychia bicolor			1
Leptophlebia		3	2
Leucrocuta		3	
Stenacron		17	
Stenonema femoratum	2	41	*
Stenonema mediopunctatum		*	
Tricorythodes			1
HEMIPTERA			
Microvelia			3
ISOPODA			
Caecidotea (Blind & Unpigmented)	1	1	
Lirceus	133	63	52
LUMBRICINA			
Lumbricina	2	*	
LUMBRICULIDA			
Lumbriculidae		1	7
MEGALOPTERA			
Corydalus	*		
ODONATA			
Argia	1		
Stylogomphus albistylus		*	
PLECOPTERA			
Acroneuria	*	*	
Agnetina capitata	*		
Amphinemura	9		3
Chloroperlidae	2		
Isoperla	4		1
Perlesta	3	1	4
TRICHOPTERA			
Cheumatopsyche	8	*	4
Chimarra	*		
Helicopsyche	5	3	3

Polycentropus	3	3	1
Pycnopsyche			*
TRICLADIDA			
Planariidae	7	3	9
TUBIFICIDA			
Enchytraeidae			1
Tubificinae		2	1
VENEROIDA			
Pisidiidae			3

Mar 09, 2021 Buffalo Creek - 0.3 mi. bl. Hereford Rd. [3273_7.7] - 21005			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	49	27	4
AMPHIPODA			
Hyaella azteca			78
BASOMMATOPHORA			
Ancylidae	1	1	3
Lymnaeidae			1
Menetus		1	3
Physella	6	21	29
BRANCHIOBDELLIDA			
Branchiobdellida	1	1	
COLEOPTERA			
Dubiraphia			2
Dytiscidae			1
Optioservus sandersoni	7	1	
Psephenus herricki	3	10	1
Scirtidae			1
Stenelmis			3
DECAPODA			
Faxonius macrus		*	
Faxonius neglectus	1	*	*
DIPTERA			
Brillia			1
Clinocera	10	3	

Corynoneura	2	7	7
Cricotopus/Orthocladius	350	42	75
Cryptochironomus		1	
Dicrotendipes		6	7
Ephydriidae			1
Eukiefferiella	6	2	
Forcipomyiinae			1
Labrundinia			2
Orthocladius (Euorthocladius)	1	2	
Paratanytarsus	2	2	20
Paratendipes		2	
Phaenopsectra		1	
Polypedilum aviceps	2		2
Polypedilum flavum	2		
Rheocricotopus	15		4
Rheotanytarsus			5
Stenochironomus			1
Sympotthastia	100	48	57
Synorthocladius	1		
Tabanus	*		
Tanytarsus	1	16	8
Thienemanniella	1	6	4
Thienemannimyia grp	2	3	11
EPHEMEROPTERA			
Acentrella	79		1
Acerpenna	5	3	4
Caenis latipennis		5	
Isonychia bicolor	*		1
Leptophlebia		*	2
Stenacron		3	
Stenonema femoratum	*	14	1
Stenonema mediopunctatum	2		
Stenonema pulchellum	5	3	
HEMIPTERA			
Microvelia			2
Ranatra fusca			*
ISOPODA			

Lirceus	9	15	37
LEPIDOPTERA			
Petrophila	1		
LUMBRICINA			
Lumbricina		*	
LUMBRICULIDA			
Lumbriculidae		1	
MEGALOPTERA			
Corydalus	*		
ODONATA			
Argia		4	
Boyeria			*
Calopteryx			1
Enallagma			1
PLECOPTERA			
Amphinemura	1		1
Isoperla		1	
Perlesta	33	14	6
Strophopteryx fasciata			*
TRICHOPTERA			
Agapetus	5		
Cheumatopsyche	3	1	1
Chimarra	2		
Helicopsyche	2		1
Hydroptila	7	1	2
Ironoquia			*
Polycentropus			*
Triaenodes			11
TRICLADIDA			
Planariidae	15	1	5
TUBIFICIDA			
Limnodrilus hoffmeisteri		7	1
Tubificinae	1	3	1
VENEROIDA			
Pisidiidae		1	

Appendix B

Fall and Spring BIOREF Biological Metric Values

Fall Ozark/Neosho EDU BIOREF Biological Metric Values					
Stream	Date	TR	EPTT	BI	SI
Big Sugar Creek - ab. Hwy 90	10/1/1997	88	29	5.1	3.42
Big Sugar Creek - ab. Powell	10/1/1997	86	29	5.1	3.41
Big Sugar Creek - Hwy E	10/5/2000	87	30	4.9	3.45
Jones Creek - 0.3 mi. ab. Newton Rd.	9/30/1998	89	28	5.7	3.64
Jones Creek - 0.3 mi. ab. Newton Rd.	9/16/1997	78	26	5.9	3.64
Jones Creek - nr. Moss Springs	9/16/1997	84	26	5.6	3.62
Mikes Creek - 0.4 mi. ab. Hwy E	10/1/1997	75	20	4.2	2.55
Mikes Creek - 0.4 mi. ab. Hwy E	9/30/1998	78	23	4.3	2.95
Mikes Creek - ab. end of Molder Rd.	10/1/1997	72	21	4.9	3.01
Mikes Creek - nr. Mouth	10/5/2000	76	28	4.3	2.8
Spring Ozark/Neosho EDU BIOREF Biological Metric Values					
Stream	Date	TR	EPTT	BI	SI
Big Sugar Creek - ab. Hwy 90	3/27/1997	83	32	5.3	2.94
Big Sugar Creek - ab. Powell	3/26/1997	91	33	5.3	3.36
Big Sugar Creek - ab. Powell	3/8/2000	96	32	5.3	3.77
Jones Creek - 0.3 mi. ab. Newton Rd.	3/20/1997	73	27	5.5	2.95
Jones Creek - 0.3 mi. ab. Newton Rd.	4/9/1998	89	26	5.1	3.5
Jones Creek - Newton Rd.	3/21/2001	80	25	5.5	3.42
Jones Creek - nr. Moss Springs	3/20/1997	89	29	5.3	3.33
Mikes Creek - 0.4 mi. ab. Hwy E	3/12/1997	70	27	4.7	3.03
Mikes Creek - 0.4 mi. ab. Hwy E	3/24/1998	80	29	4.4	3.6
Mikes Creek - 0.4 mi. ab. Hwy E	3/8/2000	93	36	4.1	3.49
Mikes Creek - ab. end of Molder Rd.	3/12/1997	65	29	4.8	2.73
Mikes Creek - nr. Mouth	3/21/2001	69	26	4.5	3.45

TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index.